TSR2

Lost Tomorrows of an Eagle

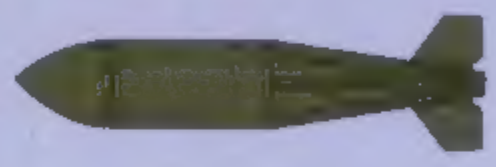
by Paul Lucas
illustrated by Andy Evans

SAM PUBLICATIONS

Conventional unguided weapons and air-to-surface missiles

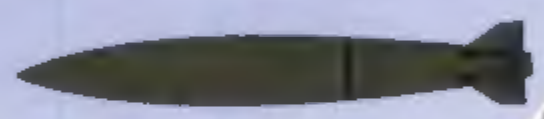
1000 lb. Mk. 6 Bomb with type 100 Mk. 6 tail
The body of RAF 1000 lb. bombs in the Mk. 6 to 12 range appear to be very similar externally, with the Mk. 10 mainly being distinguishable by its twin suspension lugs. Tails were supplied separately from the bomb bodies and could be fitted to more than one type of bomb, thus rendering identification of any given type of bomb from photographs almost impossible. The type of bomb illustrated here is fitted with the type 100 Mk. 6 tail specified for use on the TSR2.

Length with No. 100 tail unit fitted approximately 7.5ft
Maximum diameter of body , less suspension lug housing approximately 1.37ft
Tail unit span in closed position approximately 1.37 ft



1000 lb. Mk 10 Bomb with No. 117 Mk. 2 retarded tail
The Mk. 10 bomb body was of similar shape and dimensions to the Mk. 6 but its twin suspension lugs made it suitable for external carriage at supersonic speeds. It is shown here fitted with the No. 117 Mk. 2 retarded tail which made the bomb suitable for release at low level. Four arms which are pivoted at the root of the fins open backwards in the process deploying what is in effect a parachute restrained by rigging lines connected to the edge and central vent of each quadrant of fabric. All the strops and rigging lines are anchored to the tails base ring where it is connected to the body of the bomb.

Fin span of Mk. 2 for external use 23in.



1000 lb. Mk. N1 Bomb
The Mk. N.1 bomb was similar to the Mk. 10 in that it had twin suspension lugs which allowed external carriage at supersonic speeds but was both thinner and longer, thus making it more streamlined. It is shown here fitted with the No. 115 tail as specified for use by TSR2. The fins on these tails were very accurately aligned and great care had to be exercised in handling the tails to ensure that they were not damaged. The Admiralty are known to have considered this type of bomb and fin to be very expensive, which might indicate the reason that they are seldom photographed fitted to an aircraft.

Overall length of Mk. N1 bomb and No. 115 tail approximately 9.75ft.
Diameter less suspension lugs approximately 14in.
Span across fins approximately 23in.

BL755 Cluster Bomb
Following the abortive attempt to develop a munitions dispenser to NAST 1197 during the mid 1960s, the Hunting Engineering BL755 Cluster Bomb was developed to meet the continuing RAF requirement for a munitions dispenser to be used against both soft and hard targets. Entering service in 1972 the BL755 became a common sight on Tactical Strike aircraft such as the Jaguar and was used operationally during Operation Telic in 1991.

Overall length approximately 8.04 ft.
Diameter approximately 17.6 in.
Span across fins approximately 2.33 ft. It should be noted that this dimension is thought to be for a tail fitted with extensible fins in the closed position.

28 lb. Smoke and Flash No. 1 Mk. 1 Practice Bomb
This practice bomb was designed for release from high speed aircraft emitting a puff of smoke and a bright flash on impact to facilitate plotting. Six of these practice bombs could be carried by the TSR2s internally carried practice bomb carrier.

Overall length approximately 30in.
Maximum diameter of body 3.75in.
Span across fins 6.25in.

28 lb. Retarded Practice Bomb
This practice bomb was developed to simulate the delivery of retarded bombs at low level and therefore featured drag plates in place of the more usual fins at the rear of the bomb. Their greater span compared to the standard 28 lb. practice bomb meant that only four of these bombs could be fitted to the TSR2s internally carried practice bomb carrier.

Overall length approximately 27 .6in.
Maximum diameter of body approximately 3.75in.
Maximum distance across drag plates approximately 6.9in.
Length of drag plates approximately 5.25in.

36 tube 2in Launcher, Rocket, Aircraft, No.7 Mk.1 pod
The 68 mm (2.68 in.) rocket was originally developed by Thomson Brandt in the early 1950s to provide the French armed forces with a rocket of similar capability to the US 2.75 in. rocket. The 36 tube launcher originally chosen for TSR2 carried its rockets in three tiers. The first tier contained six rockets, the second tier contained 12 rockets and the third tier contained 16 rockets. This pod was used by some RAF Canberras and by the Royal Navy on the Buccaneer and Sea Vixen, though there is some question as to whether TSR2 would have ever carried it as it was not stressed for supersonic flight.

Overall length approximately 8ft.
Maximum diameter approximately 1.6ft.

18 tube 68 mm Launcher, Matra, Type M155 pod
This 18 tube launcher which was stressed for supersonic flight became a common sight on RAF Tactical Strike aircraft such as the Phantom, Harrier, and Buccaneer during the 1970s. It carried its rockets in two tiers, the first tier consisting of six rockets and the second tier containing 12 rockets.

Overall length approximately 7.75ft.
Maximum diameter approximately 1.3ft.

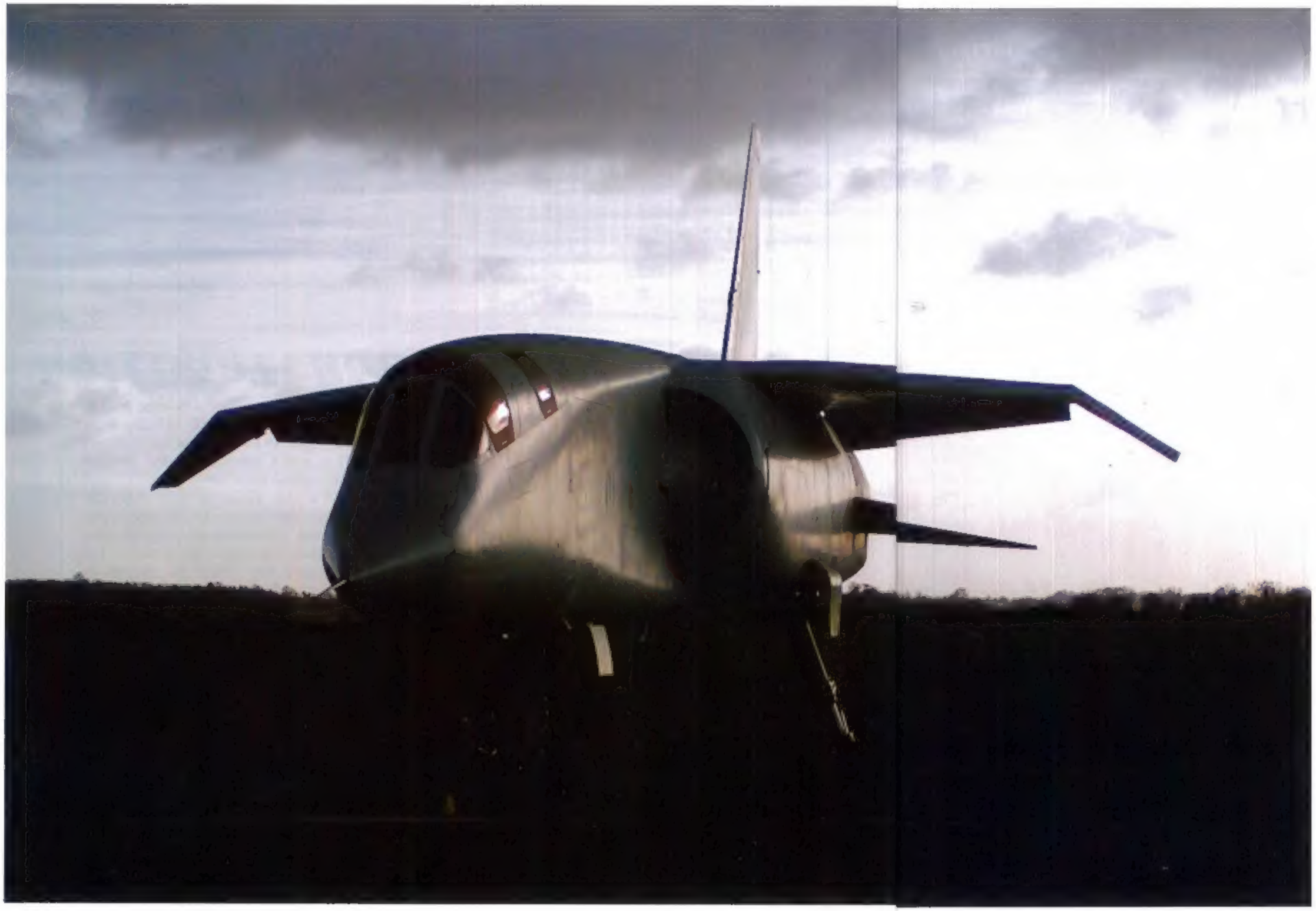
Anti Radar Martel
This version of the missile was fitted with a passive radiation seeker which automatically searched up and down a pre-set number of frequencies looking for a radar signal. When a signal was detected, the seeker locked onto it and the missile was launched. Alternatively, if the frequency of the threat was known before take off, the seeker could be fitted with a matched aerial and receiver to pinpoint the source of the hostile radiation. At one point the Air Staff were particularly interested in the carriage of two AR Martels along with the WE 177B in the Nuclear Strike role.

Overall length approximately 14.25ft.
Body diameter 15.25in.
Span 3.92ft

TV guided Martel
This version of Martel had a small TV camera in the nose which transmitted a picture back to the parent aircraft. The picture was displayed on a monitor in the navigators cockpit from where signals to guide the missile were sent as the navigator used the TV picture to guide the missile to its target.

Overall length approximately 12..69ft.
Body diameter 15.25in.
Span 3.92ft

A period BAC advert for the TSR.2 of circa 1964. The 'TSR2' logo seen in the centre of this advert has since become an icon of the project



The Duxford TSR.2 XR222 © George Sands

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TSR2

BAC TSR.2

Lost Tomorrows of an Eagle

The TSR.2 which might have been 1960–1980

BAC TSR.2 XR222 as preserved today at Duxford © George Sands

Contemporary BAC advert from circa 1964 showing the range of the Corporations aerospace products of the day including TSR.2

Author's Introduction

ON 1 OCTOBER 1963 THE LEADER OF THE LABOUR PARTY, Harold Wilson addressed the Labour Party conference which took place that year in Scarborough. The theme of his speech was 'Labour and the Scientific Revolution' which was aimed not only at the party faithful who were in attendance but also a nation-wide electorate who were expecting a general election within the next year. Towards the end of the speech Wilson used a phrase which has been widely quoted ever since. 'Socialism', he said, 'would be recast in terms of the scientific revolution' and a new Britain would be 'forged in the White Heat of this revolution'.

The Labour manifesto published two weeks previously promised a new Britain which would mobilise the resources of technology under a national plan, harness Britain's wealth in brains, genius for scientific invention, medical discovery and so on. Modernisation was the overall theme and arguably the one sphere of technology where Britain could still consider itself to be a world leader was in aviation. At the time of the 1964 election a host of advanced military aviation projects had risen from the ashes of the Duncan Sandys 1957 Defence White Paper, not to mention the Supersonic Transport, ultimately named Concorde, all of which might reasonably be expected to form the vanguard of Wilson's White Heat revolution.

Within six months of coming to power however, the new government had cancelled the three largest military projects, the Hawker Siddley P.1154 Supersonic V/STOL Strike Fighter, AW 681 V/STOL Tactical Transport and the British Aircraft Corporation Tactical Strike and Reconnaissance aircraft known as TSR.2, which were to have formed the core of a modern RAF for the 1970's, whilst Concorde only survived because it was covered by an International Treaty.

Of the three cancelled military projects, the TSR.2 is by far the best known and the story of its inception, development and downfall has been covered in some depth in a large number of books and magazine articles. What would never appear to have been done in any detail, however, is to examine what the RAF wanted the aircraft for, how it might have been deployed, what weapons it might have carried and how it might have appeared had it actually entered service. This book seeks to explore these issues through the medium of various kinds of preserved documents and artefacts which relate to the TSR.2 project.

Despite the popular view that instructions to destroy everything which were given following the project's cancellation were rigorously carried out, a large amount of material survived in government files, industry records and private hands, some of which have been used as a basis for this book. It must be emphasised in the strongest possible terms that all the documents referred to such as letters, memos, brochures, drawings and Defence Council Instructions actually exist. The plans referred to such as Plan 'P' of 1964 really were drawn up and the weapons systems were actually proposed, no matter how unlikely they may seem.

Following the cancellation of the P.1154, the earlier P.1127 was developed into the Harrier GR.1 as seen here. The Harrier entered service with No. 1 Sqn in 1969

Colour Artwork

Because TSR.2 never entered service all of the illustrations whch show TSR.2 in squadron markings are counterfactual in nature. That said, however, the illustrations are based on Primary sources such as the surviving prototype aircraft, the preliminary BAC camouflage scheme drawing of November 1964 and on the relevant Air Ministry Orders and Defence Council Instructions of the period.

The unit markings which have been applied to the illustrations of the TSR.2s given here have been drawn up with the provisions of the relevant DCI's in mind along with some artistic licence based on established practice by the units concerned and the RAF in general. More detail is given in the captions to each illustration.

It is not the author's intent to construct a cohesive counterfactual history around either the armament or operational career for the TSR.2 in RAF service. In the Spotswood scenario the Strike squadrons were apparently expected to operate equally effectively in Nuclear and Conventional roles and as this book deals with Nuclear and Conventional Weapons in separate chap-

In place of the P.1154, the Wilson government obtained the McDonnell Douglas Phantom from the USA, such as the 43 Sqn example seen here

The Lockheed C-130 Hercules was obtained as a replacement for the AW 681 Tactical Transport. The Dark Earth, Light Stone and Black camouflage was common to all Tactical Transport aircraft from 1965 to about 1975

ters, aircraft from all the Strike squadrons are illustrated as being armed with the weapons appropriate to the chapter in which the illustration appears. Thus nothing should be read into the payload illustrated on any particular squadron's aircraft though 12 Sqn has been shown as being equipped with Martel because the squadron was equipped with these missiles on its Buccaneers and Tornados, whilst 45 Sqn has been shown fitted with Martel as it was previously equipped with AS 30 armed Canberras.

Under the provisions of Plan 'P' the TSR.2 Reconnaissance squadrons were clearly defined as traditional Reconnaissance squadrons with the exception of 81 Sqn which was to be mixed Strike and Reconnaissance.

In the Spotswood scenario the distinction between Strike and Reconnaissance TSR.2 squadrons is not clear. However, it is the author's opinion that some TSR.2 squadrons would almost certainly have had to have been specialist Reconnaissance squadrons from a purely practical point of view and as there is little difference between the TSR.2 Reconnaissance requirement of Plan 'P' and the Spotswood Report it was therefore decided to illustrate the Reconnaissance TSR.2 squadrons separate from the Strike squadrons.

Many of the illustrations do not include outboard wing pylons and stores. Whilst both Strike and Reconnaissance aircraft would almost certainly have been fitted with some kind of countermeasures equipment on the outboard pylons, the exact nature of this equipment remains unclear. Whilst it is known that various proposals were put forward for various countermeasures equipment both specifically for TSR2 and for tactical aircraft in general during the period 1960-1972, much of it remains classified. As a result, the illustrations of the Countermeasures equipment given in Chapter 8 are somewhat speculative in nature.. That said, they are based on such written descriptions of the proposals for TSR.2s countermeasures as have come to light and are underpinned by such items of Countermeasures equipment as are known to have actually existed in the real world at the time.

Where either the narrative or illustrations venture away from established fact it is hoped that this has been made quite apparent to the reader.

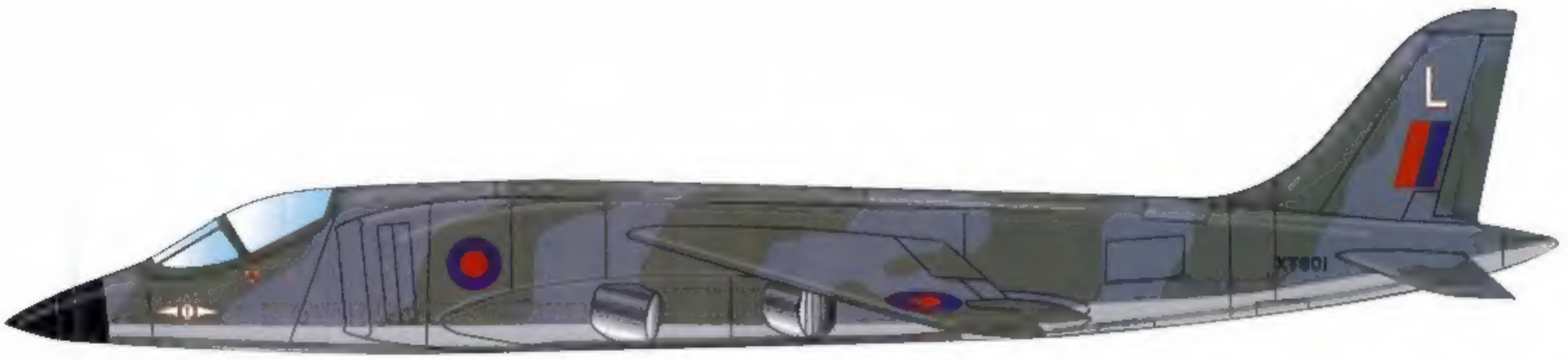
Acknowledgements

During the research for this book I have received an immense amount of help from a variety of institutions and individuals up and down the country. Thanks are therefore due to the staff of the National Archive at Kew, the RAF Museum at Hendon and Cosford, the Fleet Air Arm Museum at Yeovilton, Birmingham Reference Library, Dudley Public Libraries, Mike McEvoy, Jon Freeman, Richard Lawrence and Trevor Snowden. Especial thanks are due to Andy Evans for perseverance above and beyond the call of duty with the artwork and Neil Robinson, facilitator par excellence

After all the help I have been given by these people, any errors of fact or interpretation which remain are entirely my own.

Paul Lucas
September 2009

An echo of what should have been. BAC TSR.2 XR222 following refurbishment at Duxford © George Sands



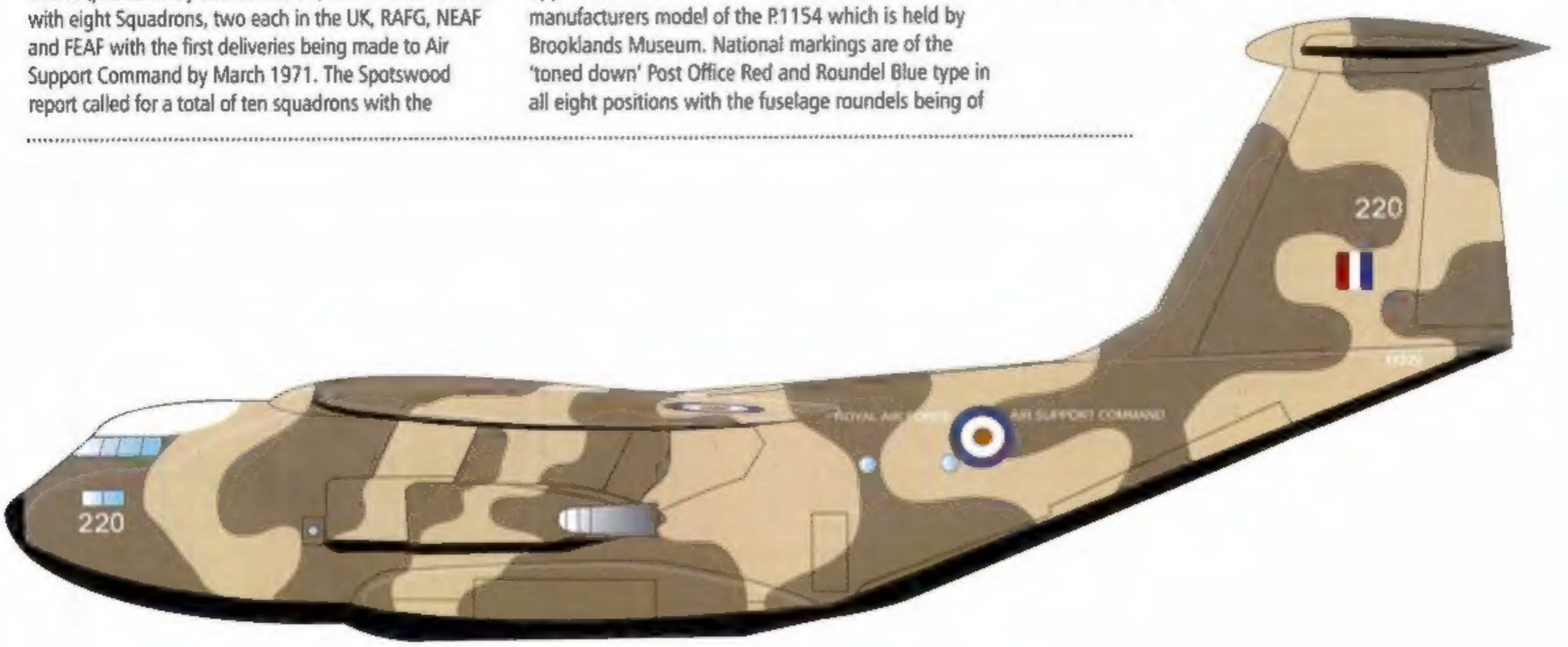
Hawker Siddeley P.1154 XT901 coded 'L' of 1 Sqn as it might have appeared circa 1971

The P.1154 was the Hawker Siddeley response to Specification AC/169 for a supersonic V/STOL strike fighter to meet the requirements of NATO Basic Military Requirement 3. This called for a single seat aircraft to be capable of flying strike missions with an additional reconnaissance and interception capability. As far as the RAF was concerned, the P.1154 appeared to be the ideal candidate to replace the Hawker Hunter and the introduction of the P.1154 to squadron service was planned to begin in March 1971.

Under the provisions of Plan 'P' of March 1964, the P.1154 (provisionally named Harrier) was to enter service with eight Squadrons, two each in the UK, RAFG, NEAF and FEAF with the first deliveries being made to Air Support Command by March 1971. The Spotswood report called for a total of ten squadrons with the additional two squadrons being based in RAFG.

The P.1154 illustrated here is camouflaged and marked in accordance with the provisions made for Fighter Ground Attack, Tactical Strike and Tactical and Photographic Reconnaissance Aircraft of DCI S.136/69. The serial number, XT901, has been taken from a batch allocated to the McDonnell Douglas Phantom FGR2s which replaced the P.1154 following the latter types cancellation. XT901 is finished in Dark Green and Dark Sea Grey on the upper surfaces with Light Aircraft Grey on the under surfaces. The disruptive pattern on the upper surfaces has been taken from that shown on a manufacturers model of the P.1154 which is held by Brooklands Museum. National markings are of the 'toned down' Post Office Red and Roundel Blue type in all eight positions with the fuselage roundels being of 24 in diameter whilst those above and beneath the wings are of 36 in diameter. The swept fin marking is 27 in high and 24 in wide. The serial number on the rear fuselage is 8 in high whilst that under the wings is 20 in high.

The squadron markings shown are those of 1 Sqn which in October 1968 had been earmarked as an Air Support Command Harrier Squadron. In the real world 1 Sqn was the first squadron to receive the P.1127 Harrier in July 1969 and the form of markings shown here are those applied by the squadron to its real Harriers circa 1971.



Hawker Siddley 681 XV220 as it might have appeared circa 1971

Operational Requirement 351 of 1961 called for a transport aircraft capable of flying a 1000 mile radius STOL sortie with a payload of 35,000lb from a main base to an airhead with a 1,500 ft unpaved runway and returning without refuelling. Three companies responded to OR351 but it was the Armstrong Whitworth submission which later became the HS.681 which was accepted for development by the RAF as a replacement for the Beverly and Hastings in the Medium Range Transport role.

Under the provisions of Plan P of March 1964 the HS 681 was intended to equip seven squadrons, three based in the UK, two in AFME and two in FEAF with the first UK based squadron being equipped by March 1971. The Spotswood report made no recommendation that this pattern be changed but did note that this force level was a minimum and the proposed time scale for the HS.681s introduction was the latest which was considered acceptable if British commitments were to be met.

The HS 681 illustrated here is camouflaged and marked in accordance with the provisions made for Tactical Transport Aircraft of DCI S.136/69. The serial number XV220 is taken from the batch allocated to the Lockheed C-130K Hercules aircraft which were ordered to replace the HS.681 following the latter types cancellation. The disruptive camouflage pattern of Dark Earth and Light Stone on the upper surfaces has been based on that applied to the RAF Hercules by Marshalls of Cambridge following their delivery from the United States in natural metal finish.

The national markings consist of a single [illegible] in diameter 1-2-3 proportioned Post Office Red, White and Roundel Blue roundel on the upper surface of the port wing, similar roundels of 54 in diameter on both sides of the fuselage and a 24 in high and 36 in wide fin marking. The single roundel under the starboard wing is of 54 in diameter but is of the 'Tactical' red and blue variety. The legend 'Royal Air Force Air Support Command' and fuselage serial number are applied in White characters 8 in high whilst the under wing serial number is applied in Light Aircraft Grey characters 36 in high with the letters outboard on both wings in the traditional manner. The last three '220' is applied above the fin marking and on the nose in White numerals 18 in high.

No squadron markings appear to have been applied to the real world Hercules which equipped the UK based Medium Range Transport squadrons of the early 1970s so none have been applied to XV220. The legend 'Air Support Command' was removed from July 1971.

Chapter 1

Policy, Planning and Prototype

THE BACKGROUND STORY TO THE ORIGINS OF THE TSR.2 AS A Canberra replacement to General Operational Requirement 339 of March 1957 is comparatively well known. So is the story of how the government used the project to facilitate a 'shotgun wedding' of the then extant multitude of British aircraft manufacturing companies which ultimately emerged as two separate groups, the British Aircraft Corporation (BAC) and Hawker Siddley Aviation (HSA).

Suffice to say that Operational Requirement 343 'Tactical Strike/Reconnaissance Aircraft' of May 1959 was written around the submissions to GOR 339 made by English Electric and Vickers-Armstrongs. The term 'Tactical Strike Reconnaissance' is said to have been chosen by the then Minister of Defence, Duncan Sandys. Whilst the significance of the '2' is not entirely clear, it might have been the result of the design which emerged being a 'second generation' of the GOR 339 concept as a result of the merging of two very similar designs. Alternatively it might have been the result of the Air Staff's primary intention with OR 343 to exploit to the full a combination of high speed and low level flying to gain all possible advantage from the difficulties which an enemy would face in mounting an effective defence against such a threat. The operational flexibility of such an aircraft would be greatly enhanced if it were to be capable of Mach 2 at medium altitude. For whatever reason, the aircraft became officially known by the acronym 'TSR.2' for the whole of its brief life.

A service name?

Had TSR.2 actually entered service with the RAF it would almost certainly have had a service name of some kind. It has been suggested that at one point the TSR.2 might have been known as the 'VELVET', an acronym somehow derived from Vickers/English Electric but this seems unlikely as a service name.

The policy on the naming of aircraft which existed in the early to mid 1960s dictated that in the absence of special circumstances, the timing of the selection of the official service name for new aircraft would be governed by two main factors:

a) A firm production commitment
b) The in-service date of the aircraft.

The announcement should not precede the firm production commitment and should not anticipate the in-service date by too long but should follow soon after the decision as to what the name should be was actually made.

Apart from the obvious point with regard to a firm production commitment which under normal circumstances followed at least some development flying by the aircraft and reduced the risk of allocating a name to an aircraft which was later cancelled, the object of this policy was simply to avoid the risk of giving the impression of either protracted development and/or delayed entry into service, or even that the aircraft was old by the time that it entered service.

During the 1950s it was RAF policy to name its Fighter aircraft by choosing a word which denoted speed, activity or aggressiveness. Examples of this policy can be found in the Swift, Hunter and Javelin. Bombers were traditionally named after inland towns or cities, examples of this policy being Lancaster, Lincoln and Canberra. This policy gave way in the mid-1950s to the new jet bombers of the period, the Valiant, Vulcan and Victor, (collectively known as the V-Bombers), being given names which began with the letter 'V', allegedly on account of their swept-back wings giving them a 'V' shape.

With the advent of tactical nuclear weapons in the late 1950s which could be delivered by comparatively small, fast Fighter type aircraft, the traditional boundary between Fighters and Bombers began to blur and by the 1960s it would appear that it had become Air Ministry and later MoD policy to name Fighter and Strike aircraft after birds of prey which were capable of killing their prey both in the air and on the ground. Examples of this practice are to be found in the Hawker P.1127 which was named 'Kestrel' circa March 1964, its developed forms which were named 'Harrier' and the Hawker Siddeley P.1182 which was named 'Hawk'.

The one exception to the practice of giving an aircraft a service name during this period was the Vickers VC10 which had been procured for Transport Command. The Air Council debated a name for the VC10 but the most suitable suggestion, 'Victoria', was considered to be too similar to 'Victor'. Thus to prevent the possibility of there ever being any confusion between the two, it was decided to retain the manufacturer's designation as a service name which had already been adopted by BOAC for the civil version.

Though the VC-10 did not have a separate Service name, the individual aircraft operated by 10 Sqn in the Transport role were all named after RAF recipients of the Victoria Cross

TSR.2's supposed replacement the General Dynamics F-111 would in all probability have been named 'Merlin', a name suggested by the then AOC-in-C Bomber Command. This name was suggested as being appropriate for the F-111 on account of the Merlin's act of sweeping its wings back as it strikes, and was considered to be the first choice as a service name by 24 April 1967 when the Air Force Board agreed to take no further action about selecting a name for the F-111K until nearer the time required by RAF practice, which was stated to be not necessary for about another year, ie April 1968. The F-111K was subsequently cancelled in January 1968.

Given that the TSR.2 was not expected to enter service until 1969 and the provisions of the policy for the naming of aircraft outlined above, it would appear that discussions as to the service name for TSR.2 would most likely not have commenced until circa 1967-68 as they did with the F-111. As TSR.2 was scrapped long before this, in April 1965, it is therefore not surprising that no documentary evidence of a possible service name for the TSR.2 has ever come to light. It would appear that a service name for TSR.2 was never put forward for consideration by the Air Council who consequently appear never to have discussed the matter prior to the type's cancellation.

It has been claimed in the past that the name 'Eagle' might have been suggested for adoption as a service name for TSR.2. Unfortunately, in the light of the available evidence and the extant policy with regard to the naming of aircraft, this appears to be entirely without foundation. This is a pity, as 'Eagle' would fit with the apparently prevailing policy of the time and in the author's opinion, it somehow seems to suit the aircraft. It would also have been very appropriate as the Eagle is the symbol of the Royal Air Force which staked so much of its own future on the future of the aircraft. Thus the title of this book 'Lost Tomorrows of an Eagle' represents what might have been for both the Service and the aircraft. Because neither the name 'Eagle' or any other alternative seems to have been officially adopted prior to cancellation, the BAC designation 'TSR.2' is used throughout this book

Defence policy

During the period of the late 1950s and early 1960s when TSR.2 was being designed, it was assumed that the defence policy of the UK would be based on the principle of deterrence of war in all its forms. OR 343 stated that by 1965 the RAF would require a new aircraft to carry out tactical strike and reconnaissance operations using both nuclear and conventional weapons enabling the RAF to continue to provide tactical support for the Army, to make an effective contribution to the North Atlantic Treaty Organisation (NATO), Supreme Allied Commander Europe (SACEUR)s forces and Britain's other regional pacts such as Central Treaty Organisation (CENTO) and South East Asia Treaty Organisation (SEATO). In addition to this, such an aircraft would also allow the RAF to deter and if necessary to fight limited wars in theatres outside Europe as part of its commitments to maintain the internal and external security of those territories for which it was responsible, to whom there were obligations or in which Britain had essential economic interests.

Thus besides operating over Europe, the United Kingdom (UK) based TSR.2 force was also to provide world-wide overseas reinforcement of British bases in Near East Air Force (NEAF), Air Force Middle East (AFME) and Far East Air Force (FEAF) and of other such areas as might be necessary in support of any one of several contingency plans which existed for the defence of these regions.

Of the regional alliances, NATO is perhaps the best known. Since its formation in April 1949 NATO's primary and enduring objective has been to deter aggression against its member states. In the early 1960s NATO strategy in the event of an enemy offensive was to respond immediately with a massive nuclear strike against both the armed forces and homeland of that enemy. Thus the RAF's tactical air power within the NATO context was no longer primarily concerned with close air support, interdiction or counter-air operations with conventional weapons, but with the employment of nuclear weapons for these purposes.

This NATO strategy was changed from 1967 when it was replaced by one of Flexible and Appropriate Response. This new strategy was intended to present SACEUR with a flexible range of options with the ability to tightly control an escalation from minimum response with conventional weapons to maximum response with thermonuclear weapons, according to the level of threat.

CENTO took its cue from the success of NATO and a continuing Cold War Soviet threat to countries of the Middle East. This threat

A USAF F-111. In RAF service, the F-111 would probably have been named 'Merlin' on account of the Merlin's act of sweeping back its wings as it strikes

initially gave rise to a Turco-Iraqi pact for mutual defence which was signed in February 1955. For various diplomatic and military reasons Britain and Pakistan both joined this treaty which became known as the Baghdad Pact in April 1955. CENTO was born when Iraq pulled out of the treaty in 1959.

Thus as part of NEAF, TSR.2 was seen as being necessary to look after British interests in the area and meet both strike and reconnaissance commitments to CENTO. In so doing, British support for its friends and allies in the Near and Middle East would be demonstrated whilst also helping to maintain the peace in what was considered to be an unstable area.

SEATO grew out of the perceived threat posed by the Soviet Union and communist China to the nations of South-east Asia and the Western Pacific area during the early 1950s typified by the Korean War and Franco-Viet Minh struggle in Indochina. Eight nations, Australia, Britain, France, New Zealand, Pakistan, the Philippine Republic, Thailand and the United States all signed the collective defence treaty which gave birth to SEATO on 19 February 1955.

FEAF's commitments thus covered an area stretching from the Timor Sea almost to the Tropic of Cancer and TSR.2 was seen as the instrument by which Britain could demonstrate its peacetime intention to deter, and wartime ability to engage, an enemy throughout the region.

An example of the limited war scenario outside Europe in an area in which the UK had a vital economic interest is the Kuwait crisis of 1961. In this instance the threat of invasion of Kuwait by Iraq was thwarted by the rapid deployment of conventional British forces by the RAF from the UK, Germany, NEAF and AFME along with naval participation by the Commando Carrier HMS Bulwark and Aircraft Carrier HMS Victorious, in sufficient strength to deter an Iraqi attack and thus safeguard one of the major sources of British oil supplies in the Persian Gulf.

The role of the TSR.2

The tasks to have been undertaken by the TSR.2 force based in Europe were primarily seen as the maintenance of a flexible tactical nuclear capability which would act as a deterrent to any Soviet aggression as part of the overall contribution to NATO which might not warrant automatic massive strategic retaliation on the Soviet homeland.

The TSR.2 was therefore required to effectively deliver tactical nuclear weapons from low altitudes at the maximum range available with minimum consideration of the prevailing weather conditions by day and by night; to effectively deliver conventional high explosive weapons as an alternative to the tactical nuclear weapons; to obtain reconnaissance information for all tactical purposes including target mapping at low altitudes under all weather conditions by day or night using radar and /or photography, and also to be capable of carrying out all of the above mentioned tasks at medium altitude as an alternative to low altitude.

The flexibility in role and tactics of the aircraft in the air were considered to be dependent upon an equal degree of flexibility on the ground. To meet this requirement it would be necessary for the

aircraft to be able to operate from small airfields with rudimentary surfaces and restricted maintenance facilities.

The only way that these requirements could be met was by the development of both the airframe, its weapons and its ground support equipment as an integrated 'weapons system' where all aspects were designed and developed concurrently and mutually.

Whilst OR 343 mentions support of the Army to be one of the roles to be undertaken by TSR.2 it was not intended to be a Hunter replacement in the close support role. This was certainly considered at one stage as described in a following chapter, but the Air Staff concluded that a smaller aircraft with a quick reaction time was essential for this task and the supersonic V/STOL P.1154 multi-role fighter evolved to meet this requirement.

An alternative strategic role?

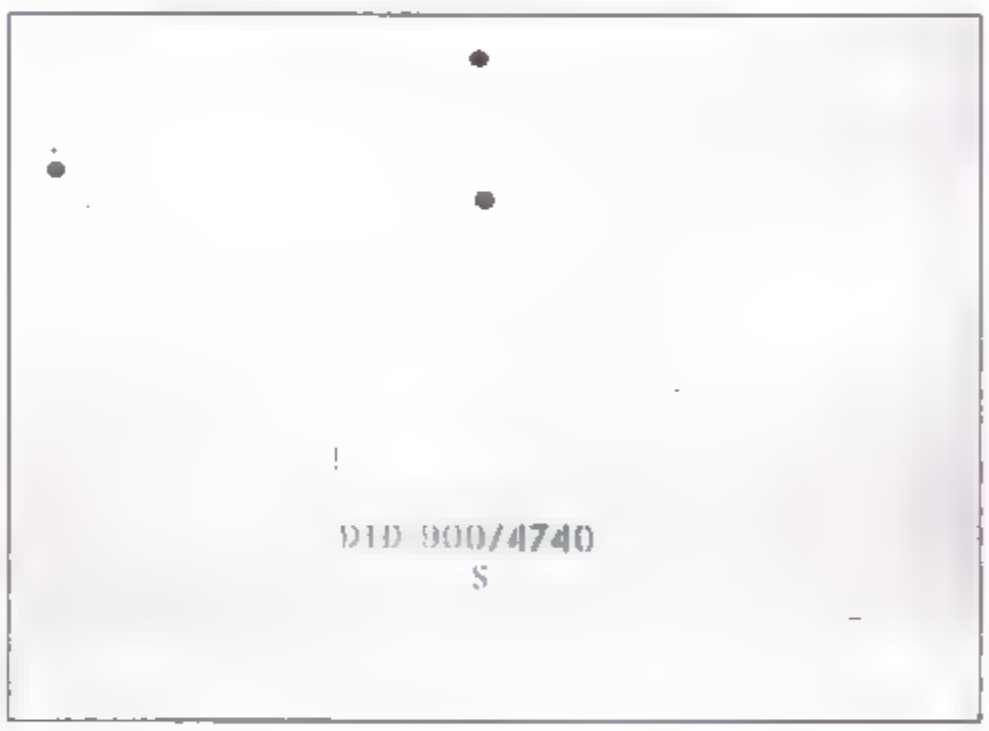
Whilst TSR.2 was designed and equipped for the Tactical Strike role there were also two distinct periods in which consideration was given to its use in the Strategic Strike role as a part of Britain's Strategic Nuclear Deterrent. The first of these was during 1960 before and concurrent with the order for the first prototypes when TSR.2 was considered as a useful supplement to Britain's true strategic nuclear deterrent, Skybolt, which was to be carried by the V-Bombers. The second was during early 1963 as a 'stop-gap' deterrent pending the introduction of Polaris following the cancellation of Skybolt during which time it was feared that the V-Bombers would no longer appear to be a credible threat in the light of improving Soviet Air Defences. Both of these periods will be examined in detail in later chapters.

Prototype colours

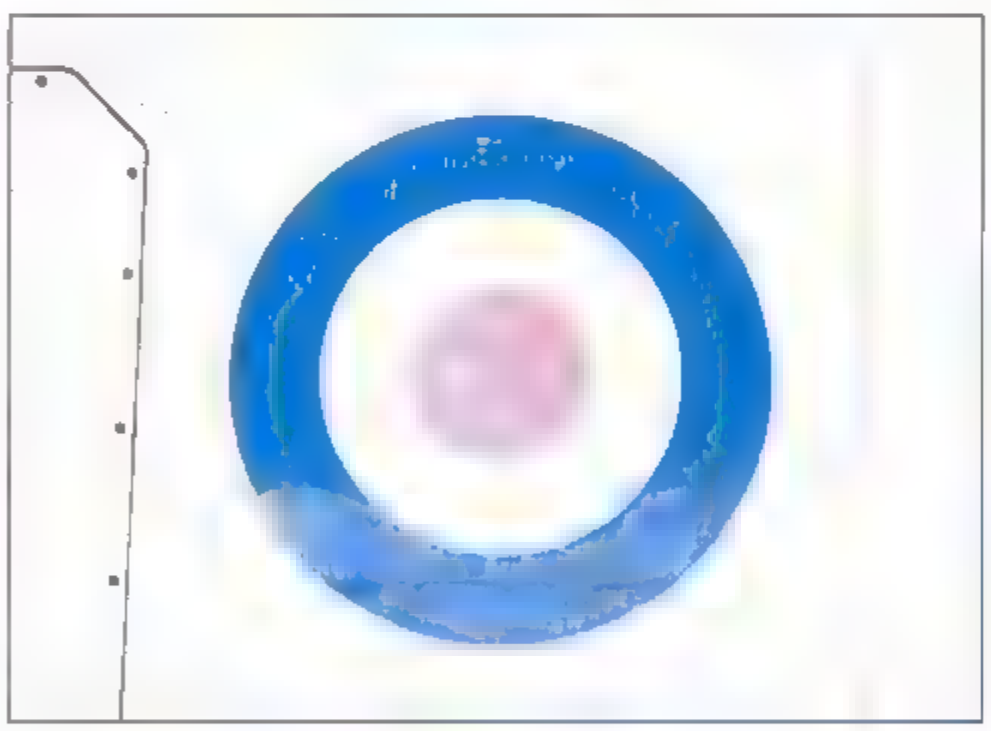
On 6 October 1960 Contract KD/2L/02CB42a for 9 development aircraft serial numbers XR219-XR227 was placed with BAC. Shortly after the contract was placed the Air Ministry issued a new AMO concerning the camouflage and marking of RAF aircraft. AMO A.239 dated 23 November 1960 described four basic colour schemes for RAF aircraft. These were White aircraft, Silver aircraft, Camouflaged aircraft and Grey aircraft.

Whilst Tactical Strike and Reconnaissance aircraft were included in the Camouflaged aircraft category, for some reason, probably related to the TSR.2's primary nuclear role albeit in a tactical context, the first nine development aircraft were finished in the overall Anti Flash White Scheme specified for Medium Bombers and Long Range Photographic Reconnaissance Aircraft.

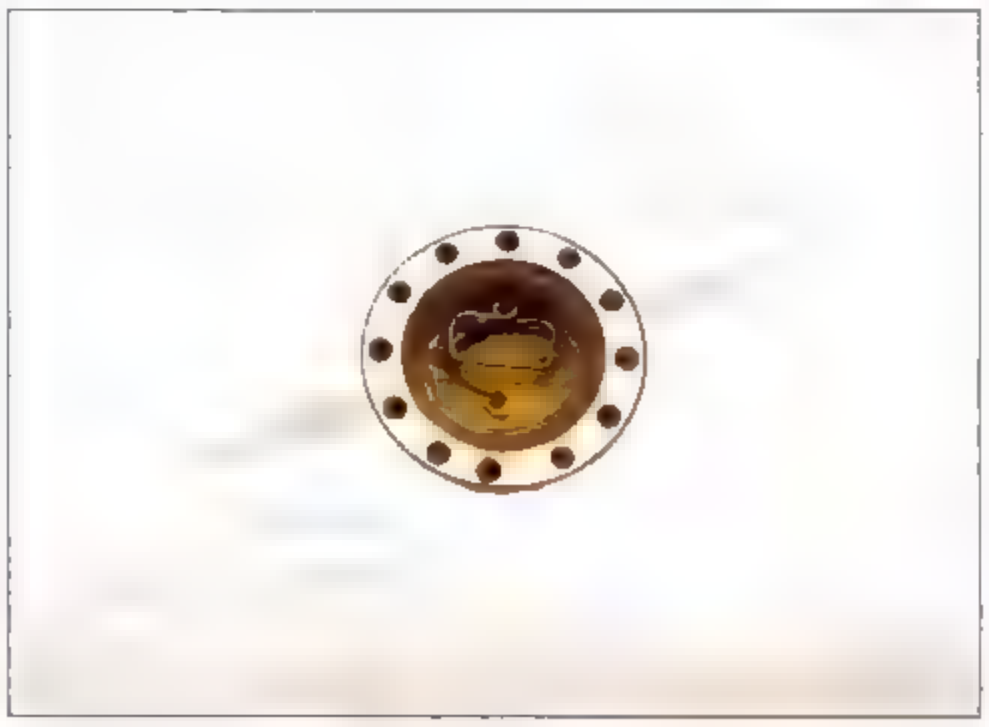
On TSR.2 this consisted of a proprietary finish for high speed aircraft under the provisions of DTD900/4740 manufactured by ICI. This consisted of a yellow chemical resistant cold cured epoxide primer, RAF Vocab of Stores reference 33B/220-2444 with a White Acrylic top coat 33B/220-2441 which covered most of the airframe except for



The DTD 900/4740/S Acrylic paint specification stencilling in Pale Blue. These eight photographs are of XR220 at Cosford which retains its original paint finish



The 36 inch diameter Pale Red/White/Pale Blue fuselage roundel



Close up of the Emergency Canopy Jettison handle under the navigator's position marked in Pale Red

The 16 inch high Pale Blue serial number presentation under the starboard wing which lies at right angles to the line of flight

the nose cone, various dielectric panels and a few areas which were to remain in natural metal, mostly around the 'hot' end of the aircraft. The national markings, serial numbers and airframe stencilling were applied in Pale Red and Pale Blue to the same specification.

These pale identification colours are thought to have been chosen from British Standard 2660 entitled 'British Standard for Colours for Building and Decorative Paints' which had been first introduced in 1955. It remained in use with various amendments until replaced by BS 4800 'Specification for Paint Colours for Building Purposes' in 1972. Colours within BS 2660 did not have names, only reference numbers, and the pale marking colours selected for use in the anti-flash scheme which were introduced from circa 1960 are thought to have been BS 2660 1-021 which was officially named Pale Red and BS 2660 8-088 which was officially named Pale Blue.

When supplied to the RAF by ICI to DTD900/4740 Acrylic, Pale Red was allocated the RAF Vocabulary of Stores reference number 33B/220-2442 whilst Pale Blue was allocated the number 33B/220-2443.

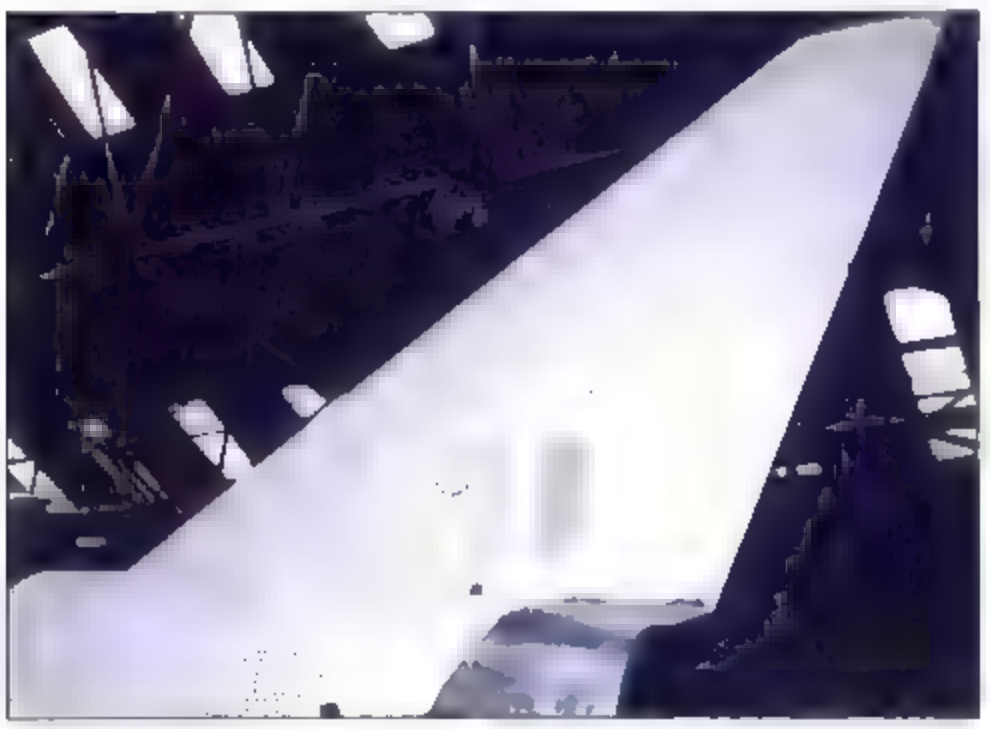
The upper wing roundels applied to TSR.2 were of 60 inches diameter whilst those on the fuselage were of 36 inches diameter, with no roundels under the wings. The fin marking was 24 inches square whilst both the fuselage and under wing serial numbers were Pale Blue characters 16 inches high.

Due to the anti-flash requirements BAC found themselves limited to the use of Pale Red and Pale Blue for airframe stencilling and warning notices. They therefore adopted the policy of reserving Pale Red for emergency notices and signs such as the ejection seat warning triangles with all other information in Pale Blue. The 'No Step' wing walkway markings initially appear to have consisted of Pale Blue lines but these were subsequently modified by the addition of Pale Red 'feathers' around their outside edge.

To what, if any, extent the acrylic finish would have been retained on production aircraft is unclear. An unspecified acrylic white finish had been applied to two Valiants as a service trial, but by October 1963 this finish had been found to be in a very unsatisfactory condition having started to flake and peel to the point where both aircraft needed to be stripped back to bare metal and repainted.

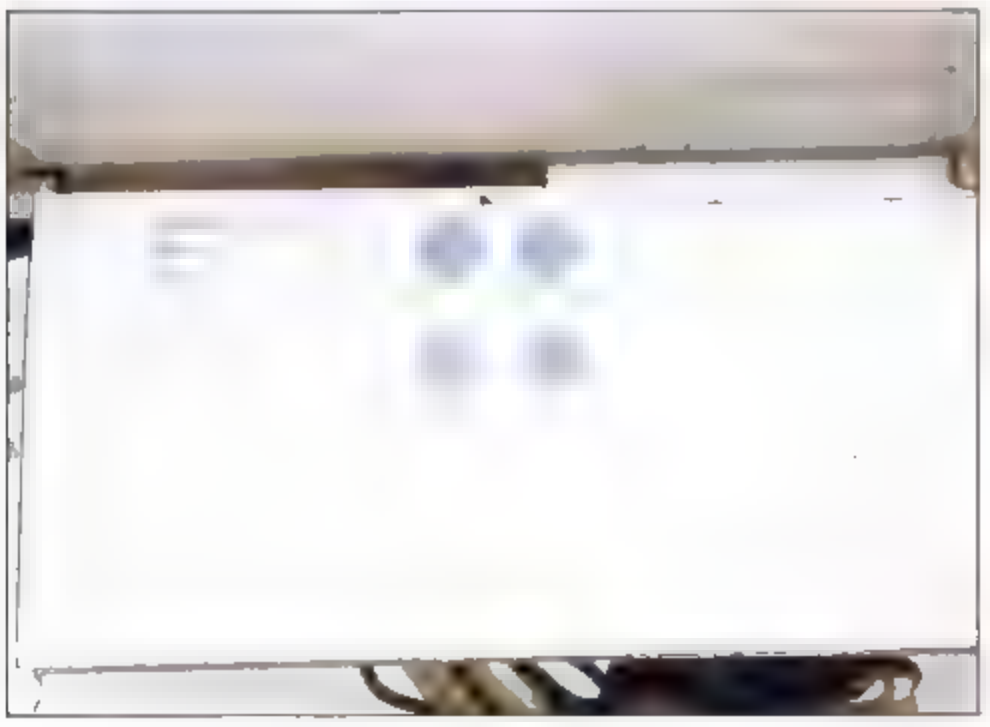
As the parent firm of the Valiant, Vickers would appear to have already been aware of the inadequacy of the extant acrylic finish by this time as a letter from Vickers Assistant Chief Engineer (Aircraft) to the Ministry of Supply Resident Technical Officer dated 27 August 1963 mentions a change in paint finish to be amongst the amendments to be shortly made to various colour scheme drawings for TSR.2.

One aspect of the colour scheme which may not be readily apparent to the casual observer is the gold tint in the cockpit canopies. The gold tint was bestowed by coating the inside of the canopy with a gold film in what was probably the first attempt to design what today would be known as 'Stealth' technology into a

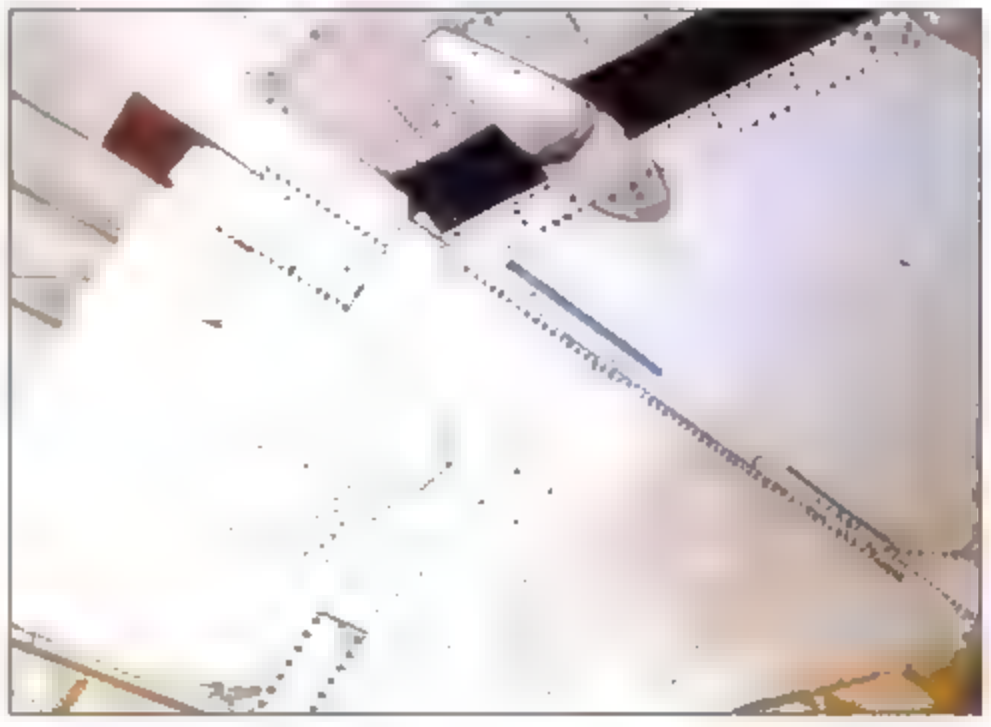


The 24 inch square Pale Red/White/Pale Blue fin marking on the all moving fin

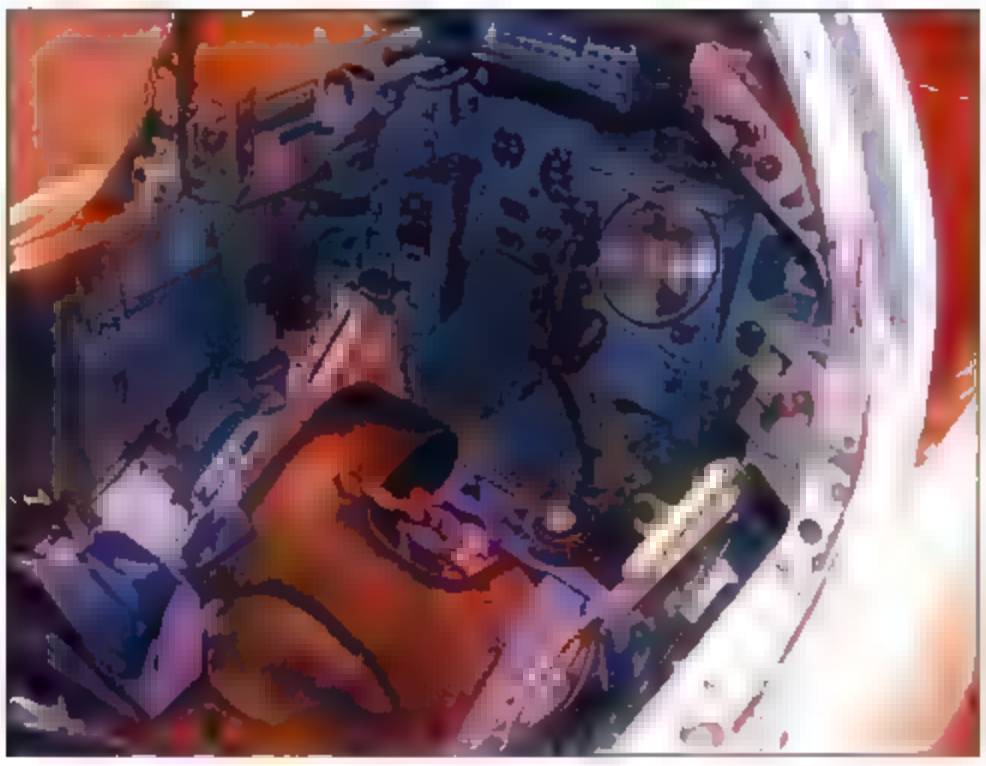
The 16 inch high Pale Blue serial number presentation on the port rear fuselage side just in front of the leading edge of the taileron



Pale Blue 'information' stencil markings on the nose wheel door



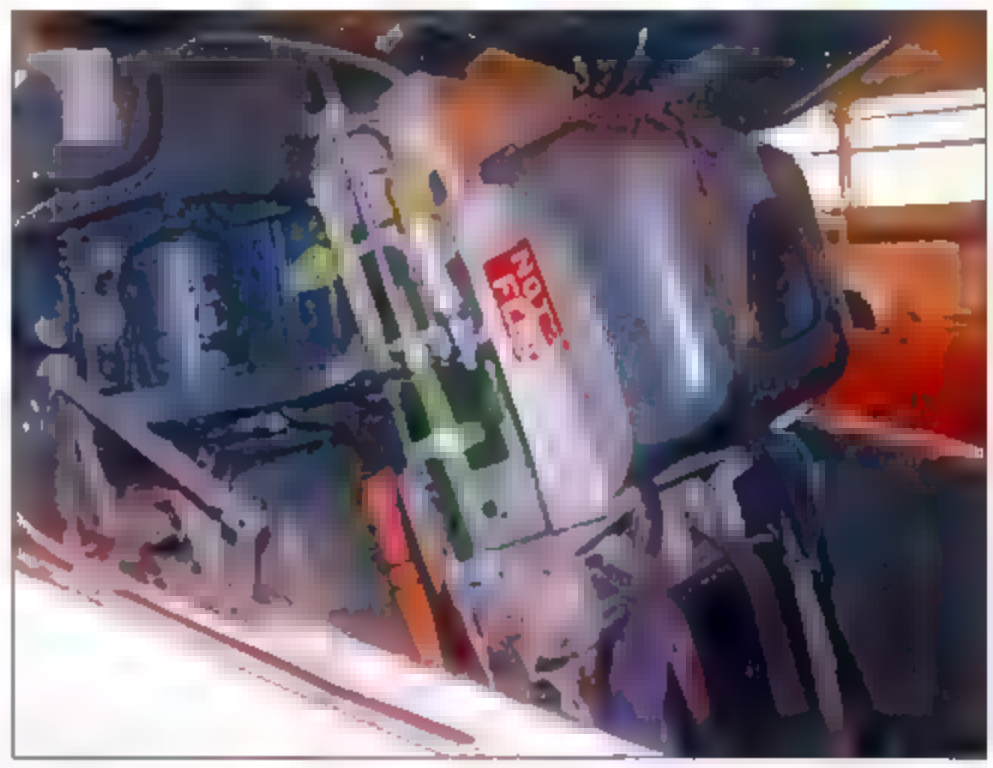
Pale Blue steadying trestle markings under the port wing tip



Forward cockpit controls. These four photographs are of XR220 at Cosford (© Trevor Snowden)

Forward cockpit ejection seat (© Trevor Snowden)

Rear cockpit controls (© Trevor Snowden)



Rear cockpit ejection seat (© Trevor Snowden)

British military aircraft intended for front line service. The gold film was intended to serve as a form of radar camouflage which would reduce or prevent an incident radar signal being reflected back from the interior of the cockpit towards a receiver. This subject will be discussed in more detail in a later chapter.

The cockpit interior was basically BS 381C No. 632 Dark Admiralty Grey as called for in AP 970 'Design Requirements for Service Aircraft' Chapter 107. This colour was to be applied to the main instrument panel, consoles and pedestals, instrument and switch mounting panels, floors, walls and ceilings, the control column, rudder bar mechanism and the headrests and cushions on the ejection seats. This basic cockpit scheme would presumably have been applied to all the production aircraft as well as the prototypes.

Financial problems

It is now widely acknowledged that the extremely high cost of the TSR.2 project played a major part in its eventual cancellation, set against the backdrop of Britain's economic decline and worsening balance of payments during 1960-65. The balance of payments problem was not a new one, having plagued successive Chancellors for many years. In simple terms there were two interlinked problems. The first was that the Pound was overvalued on the international money markets and was becoming increasingly unpopular with foreign speculators. This led to the Pound Sterling being able to buy ever less abroad. Secondly, the balance of payments was constantly under pressure from two directions. The first of these was domestic. In Macmillan's affluent society of the late 1950s and early 1960's where the majority of the British population had 'never had it so good' consumers were spending much of their disposable income on foreign imports. The second was the cost of maintaining Britain's role as a world power. During 1963 there were more British troops East of Suez than based in Germany. The biggest British base was in Singapore with another important base at Aden for operations in Africa and the Middle East.

There were also smaller bases in Bahrain, Borneo, Hong Kong and on the Maldives. Closer to home there were bases on Gibraltar, Malta and Cyprus and half way round the world in another direction on Ascension Island. All the foreign imports and the cost of maintaining Britain's world-wide presence had to be paid for in Sterling.

It was against this economic background that concerns over the cost of the TSR.2 project were being expressed in Whitehall by early 1963, as on 12 February the Minister of Defence wrote to the Secretary of State for Air on the subject. The latest reports from the Ministry of Aviation on the likely cost and delivery time scale of TSR.2 had made the Minister very doubtful whether the government should continue thinking in terms as large a buy as that then planned. (The RAF's Plan 'P' discussed below quoted a figure of 193 aircraft).

The Minister enquired whether it would be possible to restrict the production of TSR.2 to 50 or 60 aircraft and then rely on additional purchases of the Buccaneer Mk 2 to replace the remaining TSR.2s. The rationale behind this suggestion was that the Buccaneer was a much cheaper aircraft and it was available off the shelf, which meant that it could be in service much sooner than TSR.2.

The Minister wished the Secretary to examine very seriously the possibility of the RAF using Buccaneers in place of a substitute number of TSR.2s and would be very grateful for an early report on the matter.

A reply was drafted the next day in which the Secretary of State for Air expressed the view that he did not think that it would be possible to restrict the production of the TSR.2 in favour of the Buccaneer as had been suggested. The reasons for this were considered to be military, economic and political.

The military reasons

Firstly it was stated that the requirement for the TSR.2 had already been minimised with only 106 front line TSR.2s replacing 140 Canberras and 24 Valiants, with so few reserve aircraft to replace peacetime wastage that the TSR.2 front line was expected to start reducing gradually but progressively from the moment that the build-up to full strength was complete.

This was considered to be acceptable as it enabled the RAF to replace its Canberras with really advanced and up-to-date though necessarily costly aircraft which were capable of doing the job. The Buccaneer Mk 2 on the other hand would not represent any great advance on the Canberra. It was therefore debatable whether, if the Buccaneer were purchased, the size of the front line and its logistical backing could be limited in the same way as that of TSR.2. This argument was a long and involved one which was not pursued any further at that time, but the assumption was made that the Buccaneer would replace TSR.2 in the front line in a ratio of 1:1.

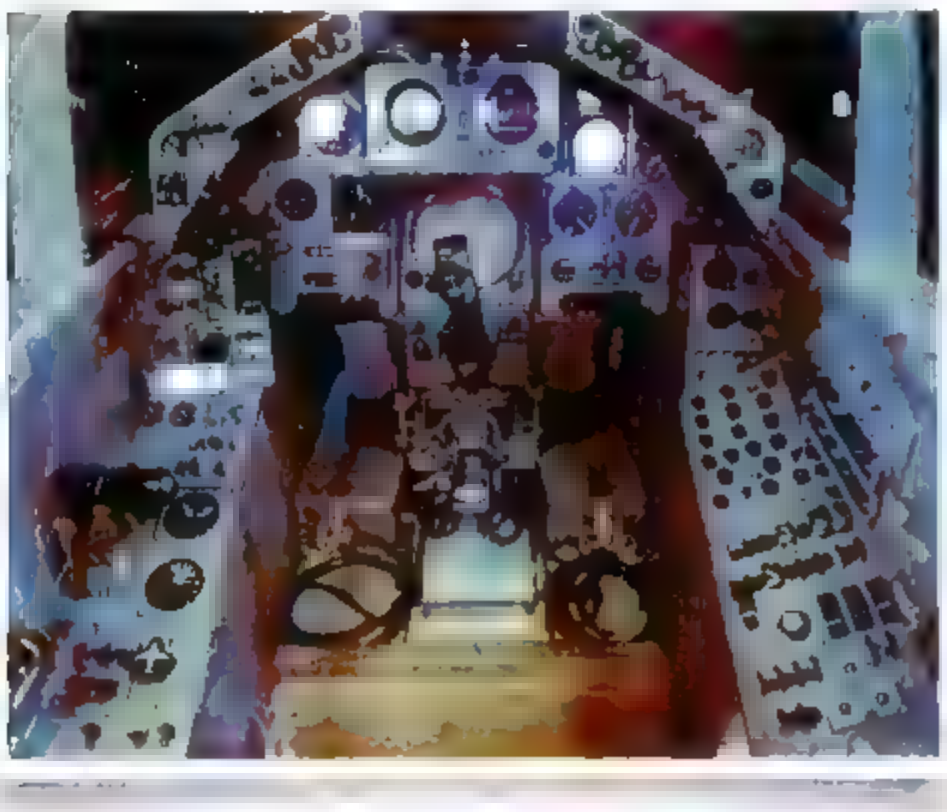
It was from the standpoint of quality rather than quantity, regardless of numbers, that the suggested substitution of Buccaneers for TSR.2s would be so unsatisfactory. This question had been examined previously on two occasions, the first between April 1958 when the requirement for TSR.2 was put forward and December 1958 when development was finally approved, and again between March and September 1960 when the previous Minister of Defence had reviewed the position prior to the Defence Committee finally endorsing the need to develop TSR.2 for the RAF.

Briefly, the Buccaneer was considered to be unacceptable for the following reasons.

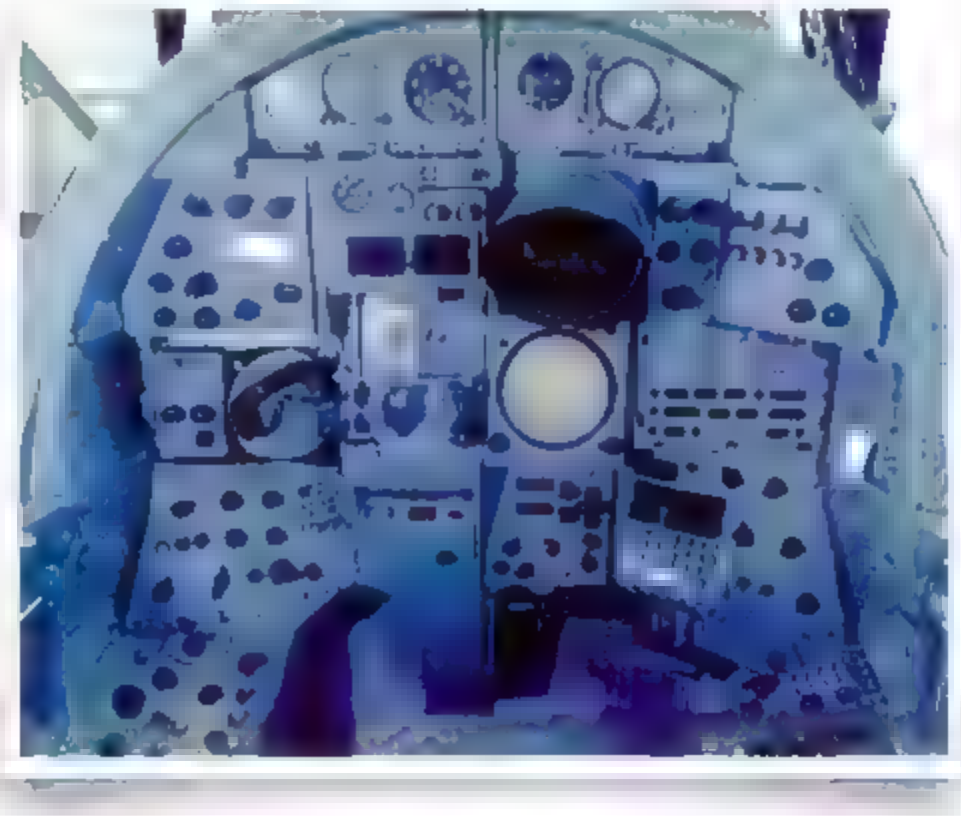
a) It would have inadequate performance to survive against the expected opposition.
b) It would have insufficient radius of action to reach all the required targets.
c) It would be tied to a comparatively small number of prepared airfields where it would be very vulnerable and would lack the flexibility to operate effectively, particularly in circumstances short of global war.
d) It would have inadequate navigation and bombing equipment for operation over land where radar response was much less clearcut than when dealing with maritime targets such as ships or harbours, unless it were fitted with equipment similar to that being developed for TSR.2 and it was thought that this might not prove to be physically possible.
e) In an aircraft designed to fly for prolonged periods at low level, handling qualities were considered crucial from the standpoint of crew fatigue and operational effectiveness. It had been estimated that the TSR.2 would be some 60-70 percent better than the Buccaneer Mk 2 during high-speed low-level flight in turbulent air conditions. Under gusty conditions over land it was considered unlikely that the Buccaneer Mk 2 could be flown to its full potential.

Summing up, it was stated that the Buccaneer had been conceived as a means of destroying enemy surface vessels, which due to force of circumstance might have to be employed for various other duties. The TSR.2 on the other hand had been conceived from the outset as a multi-role aircraft.

The 'Danger' warning triangles associated with the Ejection Seats and Emergency Canopy Jettison system marked in Pale Red



The mock up of the production pilots cockpit



The mock up of the production navigator's cockpit. The basic interior colour was dark Admiralty Grey

The Martin Baker Mk 8A Ejection Seat for TSR.2. Whilst the seat structure was essentially natural metal, the headrest and cushions were Dark Admiralty Grey

The economic considerations

Allowing for a year's slippage in the TSR.2 programme which was assumed for the purposes of the 1963 Defence Review Costing, it was expected that the RAF would take delivery of the TSR.2 in 1968/69 and 1969/70 and there would be no reduction in the numbers of TSR.2s delivered as a result of the Minister of Defence's suggestion until 1970/71 and 1972/73.

However, the problems of balancing the Defence Budget had to be faced long before these dates with any savings in defence spending needing to be made between the mid and late 1960's. If the proposal to buy substitute Buccaneers were implemented, this would lead to a rise in defence spending during the late 1960's because the unit cost of TSR.2s delivered prior to 1970/71 would rise as a result of the loss of economies of scale from cutting back on the size of the total order.

Savings would only be achieved from 1971 onwards at the expense of introducing to service in the 1970s, for service until the 1980s, an obsolete subsonic aircraft designed in the 1950s.

To give the Buccaneer Mk 2 a useful operational life in RAF service it was anticipated that deliveries would have to be accelerated and some attempt would have to be made to fit it with suitable navigation, bombing and photographic equipment. This would involve additional research and development costs on top of the production costs. In addition, it would then become necessary to start spending money earlier than would otherwise be necessary to develop a strike aircraft to replace the Buccaneer in the RAF front line before it became too hopelessly obsolete to be committed to operations of any kind.

A final consideration was that the expenditure incurred on modifying the Buccaneer would jeopardise Treasury agreement to proceeding with the development of the P.1154, since the increased expenditure which would result from the substitution of Buccaneers for TSR.2s would coincide with heavy expenditure on the P.1154 programme.

The political considerations

It was considered that the Minister of Defence need not be reminded of the Labour Party's criticism of the TSR.2 project. The Labour Party were of the opinion that the RAF should have the Buccaneer in place of TSR.2 regardless of operational considerations. The substitution of a number of Buccaneers for TSR.2s on grounds of cost at this stage would be represented as a vindication of the government's critics and an example of mismanagement and waste in the government's conduct of the defence programme.

These arguments appear to have been considered valid and the TSR.2 project was allowed to continue unaltered into 1964. Whilst the aircraft industry was getting on with building the aircraft and politicians were beginning to express their doubts, the RAF was planning the introduction of TSR.2 to service. A full picture of the RAF's plans for the deployment of TSR.2 can be gained from the plan drawn up in March 1964 for the 1964 Defence Review Costings which set out the proposed size and deployment patterns of all RAF front line squadrons for a ten-year period up to March 1975.

A Vickers Valiant in the overall Anti Flash White scheme specified for Medium Bombers and Long Range Photographic Reconnaissance aircraft by AMO A.239/60

Plan 'P'

The latest in a series of plans which were designated by letters, in March 1964, Plan 'P' stated that the total TSR.2 requirement for the period March 1964 to March 1975 was 193 aircraft, envisaged as being deployed as follows:

Bomber Command

- 2 Squadrons operating in the Light Bomber/Strike role each having 12 aircraft
- 1 Squadron operating in the Reconnaissance role with 8 aircraft. Up to 6 pre-production aircraft were to be introduced from June

1966 and retained until 1968 when they would be replaced by production aircraft. Build-up to full squadron strength, the formation of the second Strike squadron and the Reconnaissance squadron were to have been completed by the end of March 1970.

RAF Germany

- 2 Squadrons operating in the Light Bomber/Strike role each having 12 aircraft
- 2 Squadrons operating in the Reconnaissance role each having 8 aircraft.

RAF Germany was to be the focus of the first fully operational deployment of the TSR.2 with the first Strike squadron receiving 6 aircraft from March 1968 with the second Strike and first Reconnaissance squadron receiving theirs by the end of March 1969. The second Reconnaissance squadron was to be fully equipped by March 1970.

For the RAFG based squadrons the aircrew establishment was to be 18 crews on the Strike squadrons and 10 crews on the Reconnaissance squadrons. It is thought that these manning levels would be repeated in other Commands.

Near East Air Force

- 2 Squadrons operating in the Light Bomber/Strike role each having 8 aircraft
- 1 Squadron operating in the Reconnaissance role with 8 aircraft.

The first Strike squadron was to form by the end of March 1970 with the second Strike and Reconnaissance squadrons forming by the end of March 1971.

Far East Air Force

- 1 Squadron operating in both the Strike and Reconnaissance role with 10 aircraft to form between March 1970 and March 1971.

Thus the envisaged Front Line strength was 106 aircraft with up to a further 18 on the strength of the TSR.2 Operational Conversion Unit (OCU) and an unknown number in service with other second line units such as the Aeroplane and Armament Experimental Establishment (A&AEE) at Boscombe Down.

Plan 'P' stated that the total TSR.2 requirement was for 193 aircraft. This figure was calculated on the basis that aircraft wastage during the build-up to the full front line and training Unit Establishments (UE) would be replaced but that no aircraft would be bought to meet subsequent wastage. By subtracting the total front line strength and OCU allocation from the requirement, one is left with a total of 69 aircraft to form a reserve against combat or accidental loss. It would appear that the RAF expected to lose three aircraft per year through accident, so a reserve of this size would, in theory at least, allow the TSR.2 force to remain viable for over 20 years.

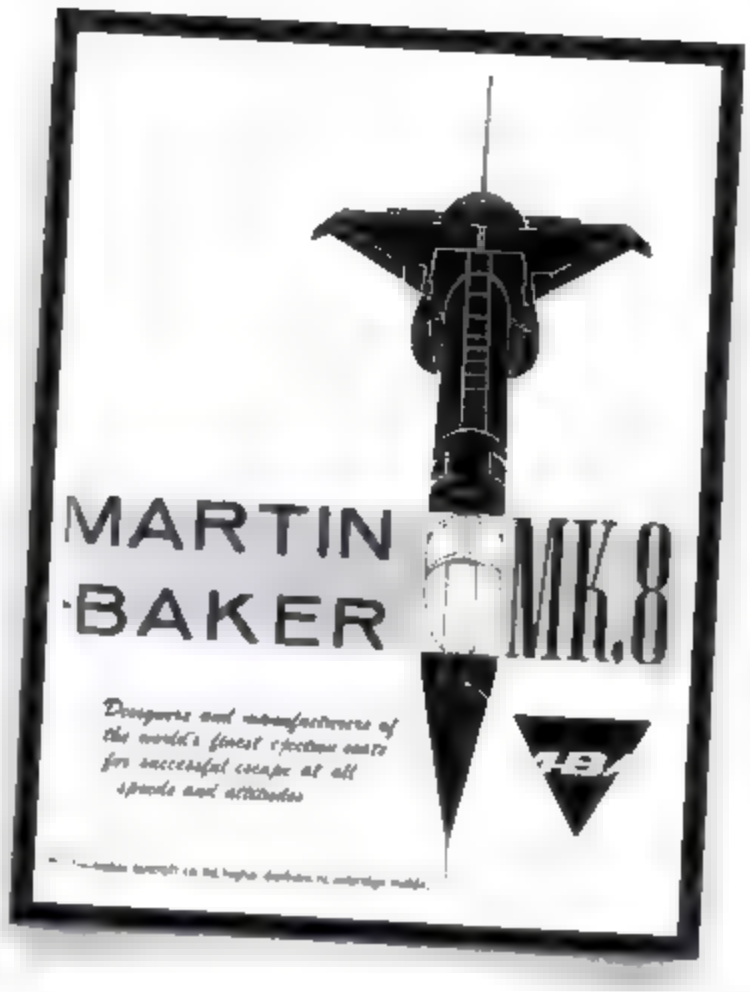
It was forecast that deliveries would be made to the following schedule: 1966-67 6 Pre-Production aircraft which would ultimately be returned for modification to production standard and were included in the total of 193; 1967-68 21 aircraft, 1968-69 44 aircraft, 1969-70 48 aircraft, 1970-71 50 aircraft and 1971-72 30 aircraft

The Spotswood Report

Even as Plan 'P' was published, the end of March 1964 saw a report, which examined the way in which the RAF might contribute to national defence policy by exercising the strategic mobility and flexibility of air power to its fullest extent in the most economical way possible up to 1980 completed and submitted to the Air Council. Officially titled 'The Future Front Line of the Royal Air Force' this report appears to have been colloquially known within the Air Ministry as the 'Spotswood Report' after its author Air Vice Marshal Spotswood.

The Spotswood Report began with a summary of the major and connected circumstances which demanded a critical examination of the requirements for Britain's air power in the future. These were perceived as being:

a) The run down of the V-force and the consequent loss of a wide and flexible capability besides nuclear deterrence which would reduce Britain's capability for a 'controlled response' on a world-wide basis.
b) Besides providing a controlled response, to also provide an element of deterrence across a broad spectrum of possible types of aggression.
c) The need for Britain to maintain her influence in world affairs consistent with her economic and political needs backed by military force.
d) The growing threat from a number of nations capable of involving Britain in a limited war, and in the case of China nuclear war.
e) The cost of weapons systems which increased more rapidly than the Gross National Product but which nevertheless had to be found from a fixed proportion of it.
f) High personnel costs.
g) The need to limit overseas expenditure as far as possible.



A contemporary Martin Baker advert for their Mk 8 Ejection Seat as fitted to TSR.2

The Strike and Reconnaissance force

The Spotswood Report envisaged that in 1966 the RAF's long range Strike and Reconnaissance force would consist of 270 aircraft of which 200 would be Strike and the remaining 70 specifically for Reconnaissance. The Strike element would consist mainly of the V-Bombers which as an alternative to its nuclear capability would be able to lift three thousand 1,000lb bombs in a conventional role. Under the existing plans the next decade or so would see a marked

TSR.2s home grown rival, the Blackburn Buccaneer S.2

change in these capabilities as the RAF's long range Strike and Reconnaissance capability would consist of about 100 TSR.2s for both functions. Thus the conventional bomb lift capability would only be a small fraction of the 1966 figure.

Whilst Britain's strategic nuclear capability would be preserved by the naval Polaris system, the UK's ability to deter lesser forms of aggression wherever it might be threatened would therefore be considerably reduced. Whilst it was envisaged that improvements in accuracy and penetration capability would make the bomb lift available to the RAF in the 1970's more effective weight for weight, it was felt that this could not make up for the smaller number of aircraft which could be deployed and the weight of attack which they could deliver under limited war conditions. It was believed that this would adversely affect Britain's ability to deter or prevent the escalation of 'brush fire' wars into limited wars, or if this occurred to operate effectively under such conditions.

Suggested modifications to Plan 'P'

It will be recalled that Plan 'P' called for 32 TSR.2s to be based in the UK, 40 TSR.2s in RAFG, 24 TSR.2s in NEAF and 10 TSR.2s in FEAF giving a total front line strength of 106 aircraft. The Spotswood Report ventured the opinion that the strength and distribution of this force was neither in consonance with the aims of British defence policy nor with the commitments that it was supposed to meet.

In NATO the assigned TSR.2s together with a number of F/GA/R aircraft were expected to replace the 24 Valiants, 88 Canberras and 16 Hunters assigned as well as a further 8 Valiants and 8 Canberras which were under RAF control but were earmarked for NATO should war break out. The replacement for these forces by TSR.2s had been worked out on a basis of 1:1 for Valiants assigned, 1:2 for Canberras assigned in Germany and 1:1 for the earmarked Canberras.

These ratios corresponded to the nuclear capabilities of the aircraft concerned. The TSR.2 was a dual carriage aircraft, i.e. it could carry two nuclear weapons. The Valiants assigned to SACEUR were also dual carriage and therefore needed to be replaced on a one-for-one basis to maintain coverage of the same number of targets. The Canberras on the other hand were only single carriage and therefore only half as many TSR.2s would be required to cover their targets.

No plans had been made for the replacement of the 10 PR Canberras assigned in the Mediterranean or the earmarked reconnaissance Valiants (later Victors). In the timescale under review, given that the sophistication of the threat could only increase, this was considered to be a very austere ratio.

In CENTO, Britain was the only major power and its contribution was 40 Canberras. It was felt that any notable reduction in the effectiveness of this contribution could lead to a weakening of resolve on behalf of the other contributing nations and perhaps lead to the increased possibility of Soviet or other military adventures in the Near or Middle East. If the general rule for NATO assigned forces of replacing two Canberras with one TSR.2 was accepted, then there would be a requirement for 20 TSR.2s in NEAF which was a reduction of four aircraft on the present plan.

As far as FEAF was concerned, the need to contain the growing strength of China and Indonesia whilst offering a significant contribution to SEATO made it clear that a force of 10 TSR.2s, even if they could be rapidly reinforced by aircraft from another Theatre, was unrealistically small. In addition to this, should another war (besides the conflict in Vietnam which was just getting into its stride) break out in South East Asia, especially in a SEATO context, tensions in NATO might be such that the dispatch of such reinforcements to the Far East might prove to be impossible politically. It was therefore thought that since Commonwealth as well as SEATO commitments had to be considered, that a force of at least 20 TSR.2s in addition to naval carrier forces would be required to provide the necessary military and political influence to deter aggression from both the north and south of the region.

A strategic reserve

It was considered that the Theatre forces described above were minimal even to provide a presence and intent under normal conditions and that the air strength of potential aggressors made it clear that these forces would be insufficient by themselves in times of tension or outright aggression irrespective of whether any of Britain's allies might be involved. Despite this, only the eight reconnaissance TSR.2s earmarked for SACEUR could possibly be considered as a strategic reserve. In a world where Britain might be called upon to support other Commonwealth countries such as India in the event of an attack, or to contain a potential enemy such as Egypt if it threatened Libya under circumstances where Regional pacts did not apply, and perhaps where assistance from Naval Aviation was not available, this situation was considered to be unacceptable.

It was suggested that a strategic reserve must therefore be provided which would remain under national control to meet the needs of reinforcement in the Near, Middle and Far East, or indeed anywhere that the rapid deployment of an obviously potent force could deter the outbreak of a limited war with its attendant possibility of escalation. Taking the eight TSR.2s earmarked for NATO which might reasonably be expected to be available for deployment in an emergency as part of a strategic reserve into account, it was suggested that a further 12 aircraft, making a minimum viable force of 20 TSR.2s, should be provided for this purpose.

Deployment

With regard to the deployment of the TSR.2 force, the Spotswood Report foresaw the advent of the TSR.2 as introducing new possibilities of combining operational, organisational and economic advantages without a loss in effectiveness. Up to this point it had been found necessary to deploy on the Continent all those aircraft assigned to Allied Command, Europe with the exception of the V-Bombers and Fighter Command, due to the range limitations of the aircraft and the consequent need to base them in a forward position for tactical reasons.

Now however, it was thought not only feasible, but desirable to consider deployment of the NATO Strike/Reconnaissance force in the UK for the following reasons.

1) The TSR.2's range and ubiquity made it unnecessary for the type to be based in a forward position on a permanent basis. By basing the aircraft in the UK instead of Germany, their vulnerability to surprise attack, which was a matter of great concern to SACEUR, would be considerably reduced. It was also argued that no attack on aircraft based in the UK by the Soviets could possibly be construed as an act of 'limited war' which would reduce further the possibility of a confrontation in central Europe.
2) The deployment of the TSR.2 force on home bases would ease the maintenance problems implicit in such a complex weapons system as well as reducing the running costs, especially in foreign exchange.
3) Full advantage could be taken of the complex of already extant infrastructure of communications, bases and dispersal airfields built for Bomber Command.
4) The strategic reserve squadrons should also be based permanently in the UK as such a deployment would then make feasible the provision of the NEAF and FEAF theatre components on a rotational basis which was thought to be desirable on both technical and economic grounds.

Summary

The Spotswood Report therefore concluded that the TSR.2 force required was 63 aircraft based in the UK assigned to SACEUR; 20 aircraft in NEAF and declared to CENTO though the individual squadrons would deploy on a rotational basis from the UK; 20 aircraft in FEAF also deployed on a rotational basis from the UK and a UK based strategic reserve of 20 aircraft of which 8 would be earmarked for NATO, thus giving a front line total of 123 aircraft.

BAC TSR.2 First prototype XR219, Boscombe Down September 1964

XR219 was one of the first ten development aircraft which were finished in the overall Anti Flash White scheme specified for Medium Bombers and Long Range Photographic Reconnaissance Aircraft by AMO A.239/60 dated 23 November 1960.

This finish consisted of a high speed finish to DTD 900/4740 manufactured by ICI which covered most of the airframe except for the nose cone, various dielectric panels and a few areas, such as the dark looking panels on the wings which remained natural metal. The national markings, serial number and airframe stencilling were applied in Pale Red 33B/220-2442 and pale blue 33B/220-2443 to the same specification.

The upper wing roundels were 60 in diameter whilst those on the fuselage were 36 in diameter. No roundels were carried on the under surface of the wings. The fin markings were 24 in square whilst both the fuselage and under wing serial numbers were 16 in high.

Airframe stencilling was applied in either Pale Red or Pale Blue with Pale Red being utilised for emergency or warning notices such as the ejection seat warning triangles whilst Pale Blue was utilised for other information such as the 'No Step' wing walkway markings.

Note the 'gold' tint in the cockpit canopies which is thought to have been a radar camouflage measure as mentioned in Chapter 8.

TSR.2 Bases

Whilst Plan 'P' and the Spotswood report outlined the deployment of TSR.2 on a Command basis, it did not specify which Stations the type would operate from. The minutes of a meeting on TSR.2 Planning and Progress held at the Air Ministry on 1 May 1963 reveal that the deployment policy as envisaged at this time foresaw that likely bases in the UK were Coningsby, Marham and Wyton.

Coningsby was chosen as the first UK base and home for the TSR.2 OCU for a number of reasons. Firstly, it met the basic airfield requirements in terms of size and facilities on site. Secondly, it was conveniently close to two designated low flying areas which would be of use to the OCU. Finally, two squadrons of Vulcans, one of the most noisy aircraft in the RAF's inventory, had been operating from there for some time without an unfavourable reaction from the public. This factor was of importance as TSR.2 was expected to be very noisy. Following the first flight, concern later came to be expressed about the possibility of operating the type at low level anywhere in the UK with the suggestion being made that this might have to be carried out entirely overseas either in Libya or even Australia. One other possible reason for Coningsby's selection which was not mentioned in the minutes was that it had the necessary secure storage for nuclear weapons, having previously been the home of 9 Sqn's Canberras which had been equipped with LABS and the necessary equipment to deploy the US Mk 7 tactical nuclear weapon under Project E. This will be discussed in more detail in a later chapter.

Wyton was of course the 'home' of RAF Photographic Reconnaissance and it is therefore not surprising that this was suggested as the base for the TSR.2 Reconnaissance squadron in 1963.

In addition to these Stations, Bassingbourn was listed as having sufficient modern static photographic accommodation with processing and printing facilities adequate for the continuous support of a TSR.2 Reconnaissance Squadron of 8 UE in October 1962, and Leuchars was apparently to be the UK master diversion airfield as of February 1963.

Bases in Germany

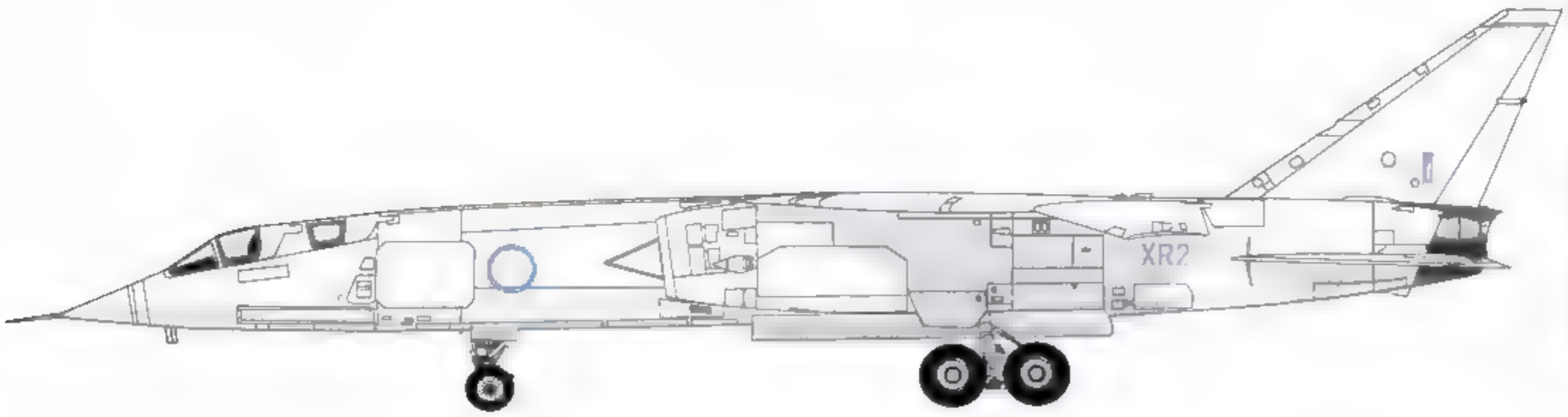
In 1963 it was envisaged whilst the OCU and an early limited Strike capability would be based in the UK, the initial build-up of fully operational TSR.2 squadrons would take place in RAF Germany. Five RAF bases in Germany were considered for the location of TSR.2 squadrons with the final choice falling on Bruggen as being the most suitable as the first. Bruggen was chosen because it already had the facilities required for Strike and Reconnaissance aircraft such as special (i.e. nuclear) weapons storage, ■ Quick Reaction Alert compound and a Mobile Field Photographic Unit. In addition it was home to a Maintenance Unit which was expected to be of considerable advantage during the introduction of the TSR.2 to Germany.

The second TSR.2 base in Germany was to be Laarbruch which had similar facilities to Bruggen. Each station was expected to accommodate a total of 20 aircraft and was listed as requiring a TSR.2 arrester barrier in February 1963.

TSR.2 bases in NEAF, FEAF and AFME

The TSR.2s allocated to the NEAF would be based at Akrotiri on Cyprus whilst those allocated to the FEAF would be based at Tengah in Singapore. Both of these Stations were listed as requiring TSR.2 arrester barriers in February 1963 and are believed to have been provided with storage facilities for nuclear weapons. In addition, both Stations were listed as capable of providing the necessary support facilities for a TSR.2 Reconnaissance squadron. Both Gan and Butterworth were also listed in February 1963 as requiring TSR.2 arrester barriers so it would seem that both were expected to regularly play host to TSR.2.

There never appear to have been plans for resident TSR.2



BAC TSR.2 Second Prototype XR220 Boscombe Down April 1964

XR220 was finished almost identically to XR219. The main difference appears to have been a more complete application of the Anti Flash White finish to the airframe. Thus the natural metal panels which had been left on the wings were not present on XR220.

There were two important structural differences between XR219 and XR220. The first was the fitting of an oblique camera to each side of the fuselage just aft of the air intakes. These cameras were intended to film various underwing store trials. These trials would probably have included separation trails for the externally carried bombs, firing trails with missiles and jettison trials of drop tanks.

The second difference concerned the undercarriage. Immediately upon landing at the end of the first flight of XR219 on 27 December 1964 with the main undercarriage upon the ground whilst the nosewheel was still in the air, the crew experienced what was described as 'a shattering vibration' which caused them to be momentarily disorientated before normal vision returned. This vibration recurred on every subsequent flight until a fixed strut was fitted between the main undercarriage leg and the rear of the bogie beam. This strut served to increase the damping and thus eliminate the severe landing vibration. This modification was tested with the undercarriage fixed in the down position during flights 21 and 22 which took place on 26 March 1965 and was found to have eliminated the landing vibration problem.

When the TSR2 programme was cancelled in April 1965, XR220 which was to have been the next TSR2 to fly was at Boscombe Down undergoing engine running tests in preparation for its first flight. By this time, the undercarriage of XR220 had been modified with a fully retracting bracing strut as can be seen here. Whether XR221 was ever similarly modified is not known, but XR222 which is preserved at Duxford was not.

squadrons in AFME but Sharjah and Khormasksar are listed as being intended for use for reinforcement of this theatre if required, with Khoromaskar being listed as requiring an arrester barrier and having the necessary facilities to support a TSR.2 Reconnaissance squadron. No TSR.2 squadrons were to be permanently resident on Malta either, though Hal Far was earmarked as an overseas training base for the TSR.2 OCU from where training flights over Libya could be carried out, thus requiring an arrester barrier, whilst Luqa was listed as able to support a Reconnaissance squadron. El Adem in Libya was also listed as requiring an arrester barrier and was therefore probably the master diversion airfield for TSR.2 units operating from Malta.

The TFX evolved into the F-111A Strike aircraft for the USAF which was ultimately to become TSR.2's American rival both in the UK and Australia

A change in plans

The Spotswood Report was quickly accepted by the Air Council and as a result of the decision not to base TSR.2 in Germany the total requirement for TSR.2 was cut back from 193 aircraft to 158. Despite the Spotswood Report's acceptance at the highest level within the RAF, the RAF's Directorate of Operations found much about it to criticise. The wrangling about the practicability of the general concept of the TSR.2 force as a flexible world wide weapon and the fine details of its implementation, between the Directorate of Operations who appear to have subscribed to Plan 'P' and the Directorate of Air Plans who appear to have had some empathy with the Spotswood scenario, continued through the summer of 1964 and into the autumn, by which time they had more immediate problems to wrestle with such as the emergence of a rival aircraft and new political masters in Whitehall.

The rival aircraft

On 14 June 1960 the USAF issued Special Operational Requirement 183 for its Future Tactical Strike Fighter which became known as the TFX. Initially intended to replace the F-105 Thunderchief, Robert McNamara who was US Defence Secretary at the time insisted that the USAF project be combined with the US Navy's Fleet Air Defence Fighter project which was to replace the F-4 Phantom. The submission made by General Dynamics was judged the best of the six tendered designs to meet the specification resulting in two separate versions of the TFX/F-111, the F-111A as a Strike aircraft for the USAF and the F-111B as a Fighter for the US Navy.

The Strike version of the F-111 was designed to fulfil a very similar role to that of the TSR.2 and it was almost inevitable that the two should come to be seen as rivals. Indeed this rivalry found expression in the competing bids from Britain and the US to sell their respective aircraft to Australia as a replacement for the Royal Australian Air Force's Canberra bombers.

The RAAF had been interested in TSR.2 from the start as like the RAF, it also had a number of Canberras which were in need of replacement. In 1963 the RAAF had just begun to re-equip its Fighter Squadrons with Dassault Mirage IIIs and would not be able to afford to re-equip its bomber squadrons until 1966 at the earliest, and probably not until 1967/68, so not only did TSR.2 match the RAAF's operational requirements, but it also matched their timescale. But for the machinations of the British Chief of the Imperial General Staff, Lord Louis Mountbatten, they would have probably ordered it, and had they done so, then TSR.2 would almost certainly have survived.

Instead of supporting the TSR.2 however, Mountbatten supported the Blackburn Buccaneer which was being developed for the Royal Navy. This support has been said to have stemmed from his desire to get the RAF to share the Royal Navy's costs in developing and buying the Buccaneer whilst preventing an increase in the RAF's share of the defence budget at the expense of the Royal Navy and its aircraft carriers. In November 1963 the Sunday Times reported that Mountbatten had 6 special cards made, 5 of which showed a Buccaneer and one of which showed a TSR.2, which he was in the habit of slapping down on the table whilst saying "Five of these for the price of one of these". Unfortunately the Buccaneer was of no more interest to the RAAF than it was to the RAF and firstly the Australian Defence Chiefs and then the politicians became completely convinced that the TSR.2 project would never be completed. As a result, the Australians ultimately opted to buy the F-111 signing a deal for 24 F-111Cs on 24 October 1963, which then took ten years to be delivered at something like three times the original price.

A new government

The loss of the Australian order, whilst not immediately fatal to TSR.2, did ultimately play a part in its demise. As already mentioned, in Britain the TSR.2 had few friends in the Labour Party which was initially of the opinion that the Buccaneer should be procured for the RAF in its place. Ultimately, it appears to have been persuaded that the Buccaneer would not be up to the job and instead became bewitched by the F-111.

It is possible to argue that the Labour Party's campaign against TSR.2 really began in earnest on 4 November 1964 when the then shadow Defence Minister, Denis Healey, made a speech at the Electrical Trades Union College at Esher in Surrey, when he launched an attack on what he claimed was becoming "an even worse scandal than the Blue Streak fiasco" and "the biggest scandal in British politics since the South Sea Island Bubble". Healey went on to demand that the Macmillan government answer two questions: 1) What would TSR.2 cost and 2) What was it for? The speech was widely reported in the press and provided political fireworks suitable for the following day. On November 5 the Daily Worker headline was 'Healey Starts Row Against TSR.2 Spending', The Daily Herald went with 'TSR.2 Under Fire', The Guardian 'TSR.2 a Scandal' and 'Healey Demands Inquiry Into Cost of Wonder Plane' in the Daily Express.

There followed what has been described as 'a carefully planned campaign against a major British industry for party political ends' which whilst carried out against the British aircraft industry in general, was largely focused on the TSR.2. Thus in the run-up to the general election to be held in October 1964, the Labour Party did its best to convince the electorate that the TSR.2 was a colossal waste of money which would fail to deliver what was promised, whilst the F-111 was a wonderful aircraft, the procurement of which would save the British taxpayer hundreds of millions of pounds.

It was against this background that the first prototype TSR.2, XR219 made its first Flight on 27 September 1964, only to be grounded for three months due to problems with the engines. This problem could not have come at a worse time, with a general election imminent and the Labour Party so opposed to the aircraft.

Whilst it seemed quite obvious that the election of a Labour government would lead to the cancellation of the TSR.2 in favour of the F-111, in a pre-election speech the leader of the Labour Party, Harold Wilson, made a statement which appeared to reassure voters in and around Preston where TSR.2 was being built that TSR.2 would not be cancelled by ■ Labour government.

It has been claimed that in the constituency of Preston (South) a leaflet was circulated which stated categorically that a Labour gov-

The Royal Australian Air Force rejected TSR.2 in favour of the F-111C as seen here

ernment would not scrap TSR.2 but when the successful Labour candidate was later challenged on the issue following the cancellation of the project it was claimed that the leaflet was issued without either his or his agents' knowledge.

The results of the 1964 General Election were very close with the Labour Party winning with a majority of just five seats. It has been claimed that if a mere 900 voters in eight crucial constituencies had either voted Conservative, or merely stayed at home, then the Conservatives would have remained in government. If this had been the case, then TSR.2 might have stood a much greater chance of survival.

Wilson's first cabinet appointment was James Callaghan as Chancellor of the Exchequer on 16 October. According to the documents he was given by the Treasury, the new government had inherited a balance of trade deficit that had been growing for some time and now apparently stood at some £800 million. The pound was under threat and severe cuts in public spending and increases in taxation were almost inevitable.

In the years since 1964 historians have generally blamed the previous Conservative Chancellor, Reginald Maudling, for the scale of the deficit inherited by the new Labour government. In April 1963 in an attempt to break out of a stuttering 'stop-go' economic growth cycle and with one eye on the impending election, Maudling had cut taxes thus unleashing what has become known as the 'Dash for Growth'. Unfortunately this led to a reckless boom in consumer spending, much of which on imported goods, which made the balance of payments situation worse, and a rise in the bank rate to 5 percent in February 1964 had little or no effect upon the worsening financial situation. When the opportunity to raise taxes was not taken in the budget of April 1964 the Treasury began to voice its concern and was asked to prepare emergency plans for whoever won the election.

Even before the full extent of Britain's economic problems had become apparent to the new government, whilst in opposition the Labour Party had promised a thorough review of defence spending. This review appears to have been begun at Chequers on 21/22 November 1964 and was completed by January 1965. At a Cabinet meeting on 1 February 1965 the findings of the Defence and Oversea Policy Committee's review of the Defence Aircraft Programme were presented to the government. At this meeting the Cabinet decided that the Hawker P.1154 supersonic V/STOL multi-role fighter and the Hawker Siddeley HS.681 V/STOL jet transport would be cancelled and Phantoms and C-130s would be obtained from the USA in their place.

The TSR.2 was a more difficult question, however. Besides the cost, there were a number of technical issues which the Committee thought needed to be resolved before a final choice could be made between the TSR.2 and F-111. The Committee had therefore been forced to conclude that the TSR.2 should continue for a few more months, with the final decision being taken in the light of additional technical information which was expected to become available during the intervening period, to which the Cabinet agreed.

Thus by March 1965 the whole TSR.2 project was hanging by a thread.

The final plan

Even before the Labour government had been elected the Conservative government which preceded it had used the decision to not base TSR.2 in Germany which followed the Spotswood Report as a justification to cut back the total number of TSR.2s yet again from Spotswood's requirement of 158 aircraft to 110 aircraft, and it was this latter figure which was inherited by the Labour government.

An MoD report dated 19 March 1965 from the Joint Service Group on Requirement for TSR.2/TFX Type Strike/Reconnaissance Aircraft in the RAF stated a requirement for 110 TSR.2/TFX aircraft. Of these, it was envisaged that 74 were to be deployed in the front line as follows:

- In the UK 24 Strike and 12 Reconnaissance aircraft at two main bases
- In NEAF 16 Strike and 8 Reconnaissance aircraft at one main base
- In FEAF 8 Strike and 6 Reconnaissance aircraft at one main base

Of the remainder, 10 aircraft would be serving with the OCU, 5 would be undergoing major repair or modification and the remaining 21 were in reserve against wastage. Given the projected wastage rate of 3 aircraft per year, irrespective of which aircraft was purchased, the fleet would have had to begin to contract by the mid 1970s unless additional aircraft could be purchased subsequently.

Whilst Coningsby remained the choice of location for the OCU for the duration of the TSR.2 project, a minute from the Directorate of Operations dated 4 March 1965 discussed the questions surrounding the future location of the TSR.2/TFX and the tanker force. Whilst Marham had been suggested as the base of the first operational TSR.2 squadrons in 1963, by 1965 Marham was being suggested as the long-term base for the RAF's tanker fleet and Honington for the TSR.2/TFX.

By 1965 Wyton was considered unsuitable for TSR.2 as since the prototype had started flying, it had become apparent how noisy the aircraft was, and Wyton was considered unsuitable for noisy aircraft.

It was now suggested that the ideal deployment for the TSR.2 was to co-locate both the Strike and Reconnaissance forces on the same airfield which would allow the RAF to work towards giving the Reconnaissance force a Strike capability and get away from the rigid outlook that they were frozen in the Reconnaissance role.

In the light of subsequent developments which saw Marham become the long-term tanker base whilst Honington was earmarked for the F-111, ultimately becoming the UK Buccaneer base, it would appear that whilst Coningsby would remain the base for the OCU, Honington would have been the most likely base for the operational TSR.2 Strike and Recconnaissance squadrons.

It would appear that the plans to base the TSR 2s allocated to the NEAF at Akrotiri on Cyprus and those allocated to the FEAF at Tengah in Singapore continued to stand.

In addition to these main bases, it might be reasonable to assume that TSR.2 could have been deployed to any of the world-wide network of RAF bases on a temporary basis.

In the event, the only RAF station where a TSR.2 unit did actually form was RAF Helmswell. A long standing Bomber Command Station, Helmswell had been home to the Thor Ballistic Missiles of 97, 104, 106, 142 and 269 Squadrons between December 1958 and May 1963. Following the decision that the TSR.2 force would begin to form in Bomber Command instead of RAF Germany as advocated in the Spotswood Report, Helmswell was selected as the location of the Ground Training School and became active in this role on 1 October 1964 when the TSR.2 project team was posted in from Weybridge. Courses for ground crews began in January 1965 by which time the Training Headquarters and training aids were fully viable. The whole operation was shut down following the scrapping of the TSR.2 project in April 1965.

Decision

With the first prototype now flying and several other pre-production TSR.2s approaching completion, on 10 March 1965 BAC submitted a

revised estimate of delivery dates for production aircraft. Starting in April 1968, it proposed the delivery of one aircraft per month for the rest of the year except for November which would see the delivery of two aircraft, a total of 10. 1969 would see two aircraft per month delivered except for January and July when only one would be delivered, September, October and November when three aircraft would be delivered and December when two would be delivered giving a total for the year of 25. A further 37 were to be delivered in 1970 and 28 in 1971 bringing the total number of production aircraft to 100. With the refurbishment of some of the pre-production aircraft to bring them up to full production standard this production run would thus meet the RAF requirement for 110 aircraft.

It would appear that this production programme was the one forwarded to the MoD for subsequent use as part of the basis on which the final TSR.2/TFX decision was taken at two Cabinet meetings, one in the morning and the other in the evening of 1 April 1965. During the morning meeting a Memorandum by the Secretary of State for Defence entitled 'The TSR.2 or the F-111A' was put before the Cabinet summarising the political and economic pros and cons of cancelling the TSR.2, which served as a basis for discussion. Though the memorandum concluded with a recommendation that TSR.2 be cancelled, no decision was reached during the morning and discussion resumed in the evening session.

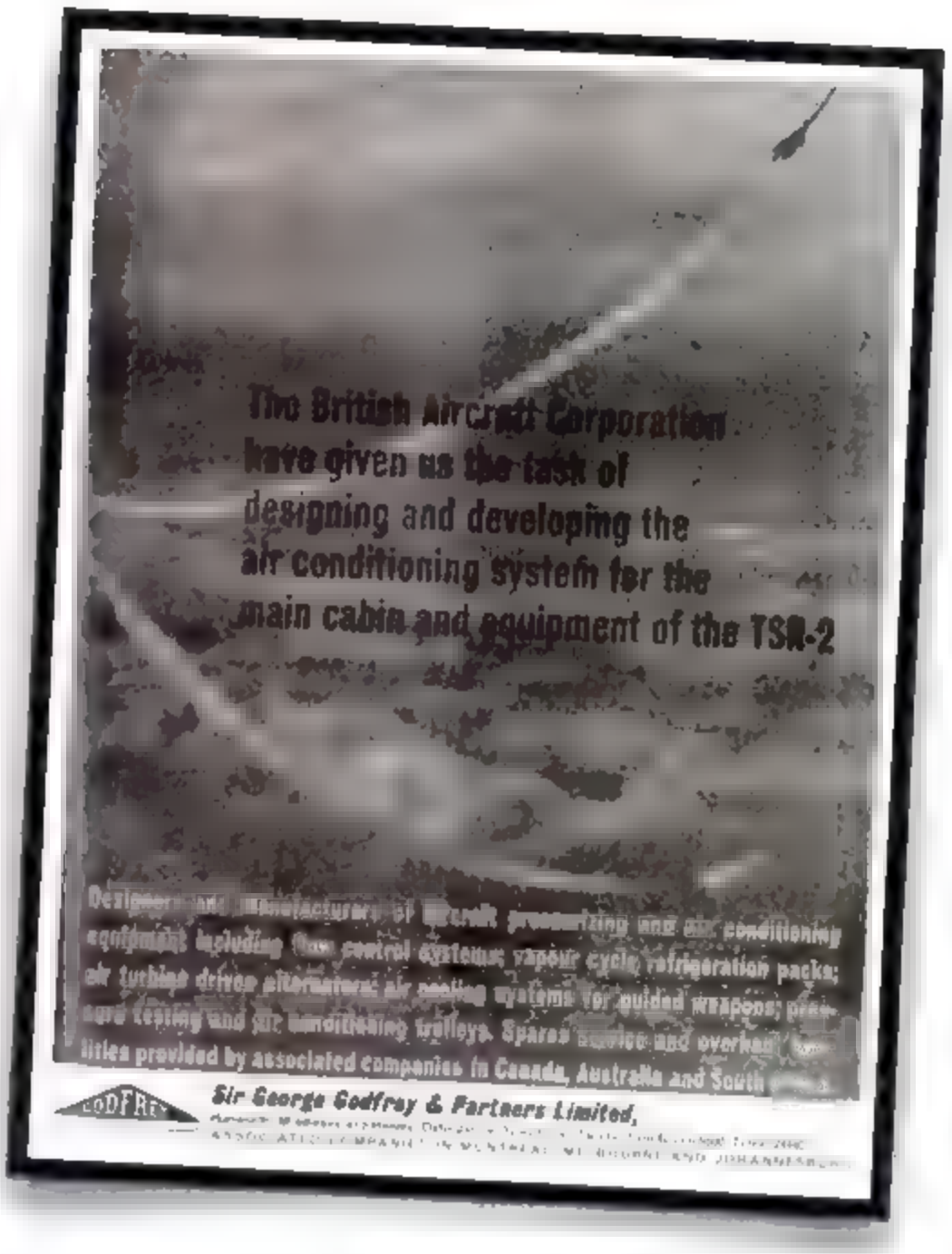
In summing up the discussion that evening, the Prime Minister said that two possibilities could be excluded – completing TSR.2 and cancelling it whilst replacing it with an immediate order for 110 TFX. There were therefore three choices: cancel TSR.2 and take no action over a replacement, cancel TSR.2 and secure an option on TFX, or postpone the decision yet again until a review of Britain's overseas commitments could clearly demonstrate whether there was a requirement for this type of aircraft at all.

These three alternatives were then discussed with a balance of opinion eventually forming that TSR.2 should be cancelled and an option taken out on the TFX. The Cabinet therefore agreed that the Secretary of State for Defence in consultation with the Chancellor of the Exchequer and Minister of Aviation should formerly confirm with the US the terms for an option on TFX, especially that these would involve no commitment to purchase any aircraft at that time. They also agreed that TSR.2 should be cancelled and that this would be announced by the Chancellor in his Budget speech on 6 April 1965.

An Eagle falls

In the introduction to the Budget, the Chancellor stated that Britain had suffered from a weak balance of payments for many years, being more often in deficit to overseas countries than not. The declared strategy of the Budget was to get rid of the deficit which in the last year had amounted to £475 million and which would have been over £800 million if Britain had not been relieved of the interest payment on a North American loan. This was to be accomplished by two means. Firstly a range of measures to raise taxes such as the introduction of corporation and capital gains tax and increased duty on beer, spirits, tobacco and car licences, expected to produce an extra £475 million, and secondly there were a range of measures to reduce public expenditure such as the cancellation of TSR.2.

Contrary to popular belief, the cancellation of TSR.2 was not 'tucked in the Budget between an extra sixpence on cigarettes and four shillings on a bottle of whisky' as one aviation historian has so memorably, but inaccurately put it, but instead between the introduction of a new Post Office Savings Bank Account and a discussion of Public Spending as a whole. The original Budget statement relating to the TSR.2 was quite lengthy and had to be considerably shortened as the Budget speech as a whole would run to more than two hours. According to the fourth and final draft of the Budget speech seen by the author, the Chancellor's statement was as follows: "I now come to the TSR.2. The Government have decided to cancel the project forthwith. I propose to refer today only briefly to the main issues.



TSR.2 was a prestige project which many aircraft systems firms were proud to be associated with

The TSR.2 project assured an advanced aircraft of high performance and I am well aware of the technical skill and devotion that have gone into it. But we have so far spent some £125 million on it; and we are faced with large continuing expenditure to produce a comparatively small number of planes. We have decided that this is not a sensible use of our overstrained resources.

The effect of this decision is to reduce Government expenditure by £35 million in 1965/66 even after taking account of the terminal costs which may become due to be paid this year. Over the next five years the decision will release (from several hundred factories) production resources of an advanced kind now estimated at more than £350 million.

There will inevitably be a significant number of redundancies in the aircraft industry. Employment conditions generally are at the moment very favourable and the intensity of demand for highly skilled men of the kind who are working on this project has been shown by the eagerness of employers to recruit the men who have been released by our earlier aircraft decisions.

(There will of course be consultations with the Trade Unions and management): my rt. hon. Friend the First Secretary of State and other Ministers will be ready to act so as to ensure that there is the least possible delay in absorbing all who become redundant into employment where they will contribute to exports and the growth of the economy".

Thus the ultimate cause of TSR.2's downfall seems not to have been one of a post-imperial socialist political ideology as has been suggested by some commentators but one of money. During research for this book, the one constant theme which runs through the preserved files seen by the author is the sheer cost of the project. It is impossible to try to quote a figure for this as there are so many ways of attempting to do so, none of which can really be considered as definitive. Perhaps the best that can be done is to say that whatever the cost was, it would appear to have been one the country could not afford.

Chapter 2

Consideration as a Deterrent During 1960

ALTHOUGH TSR.2 WAS DESIGNED AND INTENDED FOR USE AS A Tactical Strike and Reconnaissance aircraft, it would appear that its potential as a strategic bomber was recognised at a comparatively early stage by the Air Ministry. On 16 October 1957 an internal memo within the Directorate of Operational Requirements suggested that perhaps the aircraft should not be restricted to carrying only the Red Beard tactical nuclear weapon.

Whilst the requirement stated that the aircraft to GOR 339 should carry Red Beard and conventional weapons in the tactical role, it had been noted that the Deputy Chief of the Air Staff had observed that an aircraft such as GOR 339 with its range increased by flight refuelling could pose a credible low-level threat to the Soviet Union and thus contribute to the primary deterrent.

It was suggested that any contribution to the primary deterrent during the mid 1960's must be thought of in terms of megaton yields and for this capability to be built into TSR.2 from the start. Whilst at first sight the size and weight of such a weapon might seem incompatible with the concept of such a high performance aircraft it was thought that this was not necessarily so.

It was suggested that it might be possible to manufacture a megaton bomb using an Orange Herald warhead with a diameter approximately 6 inches greater than that of Red Beard and an overall length some 2 ft longer which still lay within the normal bomb load weight of 4,000 lb called for in the GOR.

The memo went on to speculate that within the service life of TSR.2 what is described as a 'British ballistic missile' would materialise and that the two weapons systems (TSR.2 and missile) would be complementary. In addition, future nuclear weapons with megaton yields might be even smaller and it was therefore suggested that the GOR be amended to give it a megaton capability.

Ballistic missiles actually entered service with Bomber Command in 1958 in the form of the US Thor supplied under Project E between 1958 and 1963, whilst from 1955 Britain had embarked upon the development of its own Intermediate Range Ballistic Missile, Blue Streak. Though based on US technology which in turn harked back to the wartime German A-4 (V2) rocket, the Blue Streak was to be designed and built in Britain. Design and construction of the structure of Blue Streak was centred on de Havilland's Hatfield site whilst Rolls Royce were responsible for the development of the engine. To this end a large test complex was constructed at Spadeadam in Cumbria, though due to the overcrowded nature of the British Isles, flight trials were to take place from the Woomera missile range in Australia.

The major problem with Blue Streak lay in its Liquid Oxygen propellant which needed loading into the missile immediately prior to launch as otherwise its very low temperature was likely to freeze various components of the missile. This however took a period of approximately 15 minutes, when only 4 minutes warning of an impending hostile strike was likely to be available. Various solutions were put forward to counter this such as basing the missiles on the seabed, on trains and ultimately in silos. For various reasons none of these solutions were found to be acceptable and in February 1960 the Cabinet Defence Committee discussed whether to cancel Blue Streak and if so, what should replace it. The decision was ultimately taken to cancel Blue Streak on account of its cost, inflexibility and relative vulnerability and therefore in April 1960 the House of Commons was told that Blue Streak had been abandoned and that an attempt would be made to obtain the 1,000 mile range Skybolt missile from the USA in its place.

Skybolt's great attraction was that it was intended to be fired from an aircraft and so could be fitted to the V-Bombers which would then continue to operate from the RAF's existing extensive airfield infrastructure, which had been built up at great expense, for the foreseeable future.

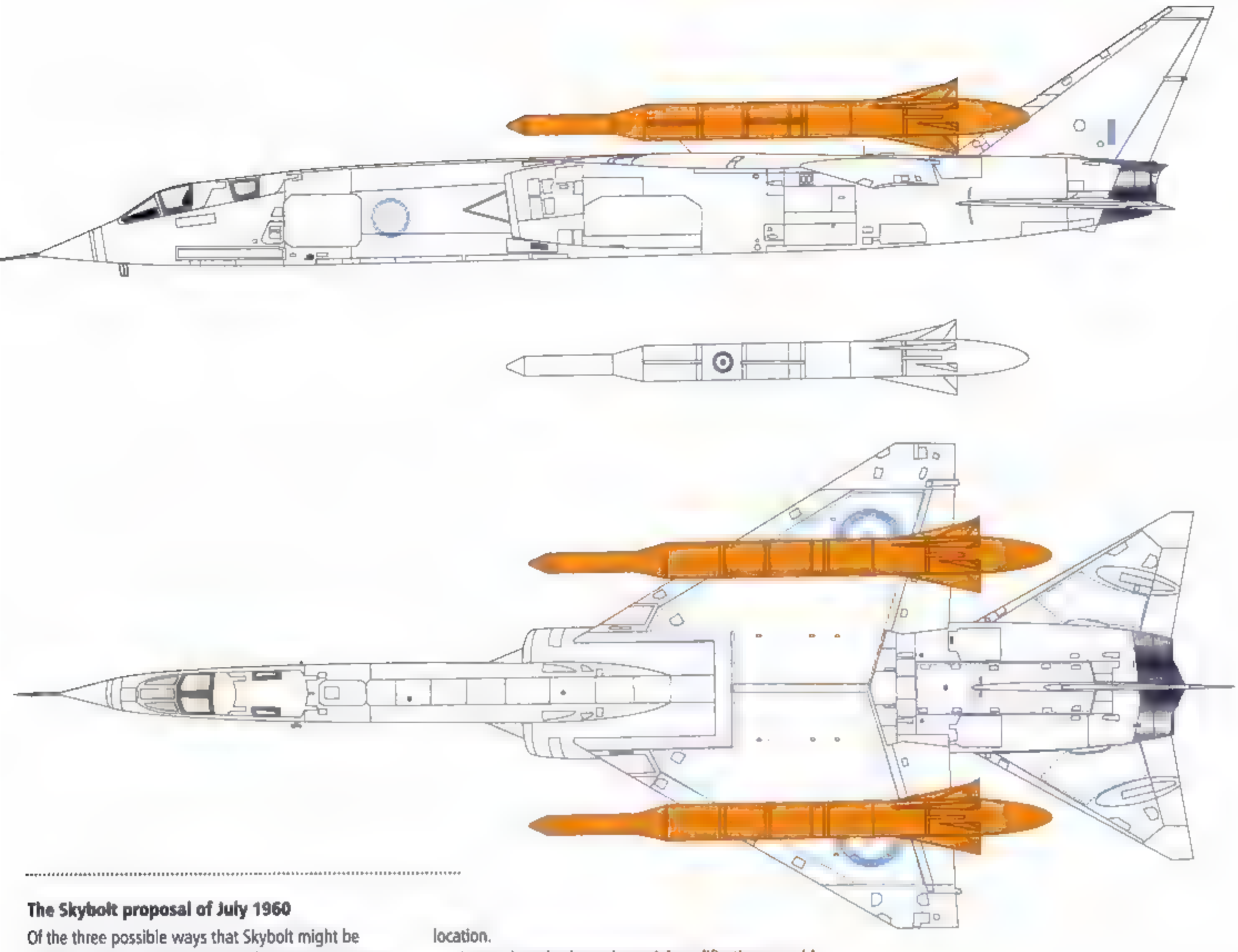
Despite reluctance by the US to allow an independent Skybolt as they would rather it were used in a NATO context, Prime Minister Macmillan was able to obtain an agreement from President Eisenhower that Britain would be allowed to purchase Skybolt without warheads, at a meeting held at Camp David in March 1960.

Although committed to Skybolt, Britain did not put all its eggs into the one basket as it was realised that the possibility existed that Skybolt might fail for some reason, and a belief was widely held that ballistic missiles might prove vulnerable to anti-ballistic missile systems which might themselves be fitted with nuclear warheads.

The Ministry of Aviation therefore carried out an assessment of the potential strategic capability of the TSR.2 during the summer of 1960 and the initial findings were set out in a report dated 20 July 1960. This stated that strategic capability must be interpreted as the ability to drop a megaton warhead on major Soviet cities from bases in the UK. In order to provide a megaton capability for TSR.2 it was suggested that the tactical weapon to OR 1177 (which was to become the WE 177) could be fitted with the small first-stage warhead from OR 1179 (Skybolt) of something over half a megaton yield.

At this time, the RAF was committed to the carriage of the US Mk. 28 weapon with a laydown capability and the yield of this weapon might possibly be as high as 1.1 megatons although the use of this weapon would have Project E conditions attached to it in war.

The Skybolt missile was Britain's Strategic Nuclear Deterrent weapon of choice in 1960. This preserved example is displayed as part of the Cold War exhibition at RAFM Cosford



The Skybolt proposal of July 1960

Of the three possible ways that Skybolt might be carried by TSR.2, carriage above the wing in a manner similar to that shown here was considered the most practicable. The exact design of the installation is not known and the overwing pylons shown here should be regarded as being representative only. They are shown as being located above the conventional under wing pylon location points as this seems the most plausible location.

It was thought that substantial modifications would need to be made to the fin, presumably to increase its surface area to counteract the shielding effect of the missiles and resulting lateral instability, but as the exact form that these modifications might have taken is unknown, the standard fin is shown.

It would therefore be possible to argue that equipped with these higher yield warheads, that TSR.2 as it then existed went a long way towards providing a strategic capability. This was due to the low altitude flight of which it was capable giving it a chance of penetrating the defences around major Soviet cities, whilst its take-off performance when operating from major airfields made it possible to overload the aircraft with fuel to extend its already long range to that which might be necessary for strategic operations.

It was realised however that an attempt to give TSR.2 a more effective strategic capability for the future must involve equipping it with a propelled weapon fitted with a megaton size warhead. The weapon should have a sufficiently long range that the combined range of the weapon and TSR.2 being flown at low altitude would be sufficient to allow the combination to penetrate Soviet occupied territory, whilst the weapon alone penetrated the final concentrated defences around the target.

Some superficial consideration had been given to the carriage of the following weapons and to the performance of the resulting system.

a) Skybolt
b) Blue Steel
c) A new ballistic weapon on the lines proposed by Vickers
d) A scaled down version of Blue Steel

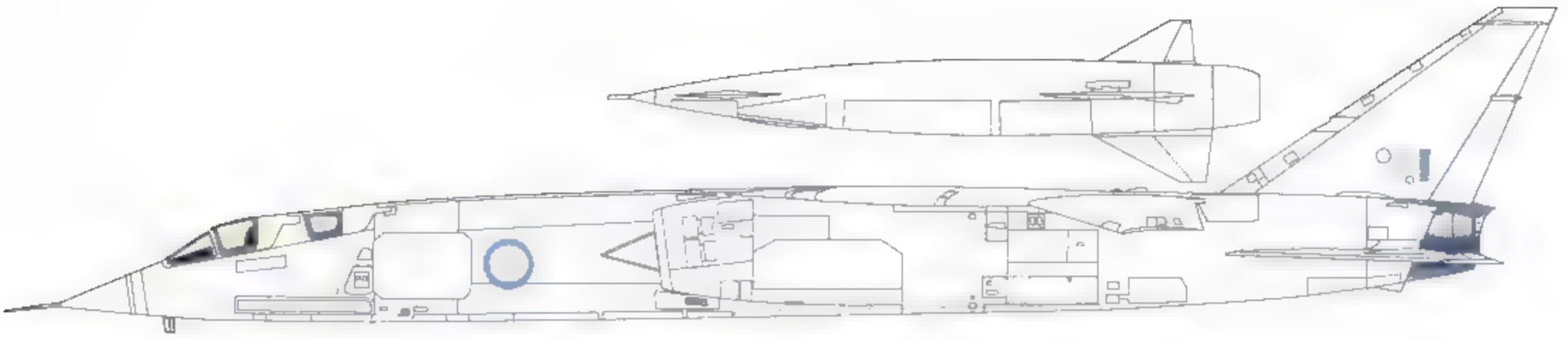
Skybolt

As far as TSR.2 was concerned there were three possible ways of carrying Skybolt: under the fuselage, under the wings, or over the wings. Each of these options would cause difficulties of one sort or another.

If the Skybolt were to be carried under the fuselage the star tracker could not be used, the aircraft Doppler would not function as it would be masked by the missile and there would be no ground clearance for the missile fins which would have to be redesigned. The longitudinal and lateral stability of the aircraft was also a matter of some doubt.

Whilst it had been suggested that Skybolt might be operated without using the star tracker by accepting a shorter range with less accuracy, Skybolt's minimum range was so great that it would be impossible to achieve the necessary accuracy and in any case, the problem of the aircraft Doppler on which it depended for accurate navigation would still remain.

The objections to the under-wing position were rolling due to a lateral shift in the centre of gravity and buffeting of the tailplane which would be directly in line with the rear of the missile. Also, it was thought likely that there would be some loss of wing lift and the aircraft and missile combination was also likely to have a low drag-critical Mach number. Wind tunnel tests were felt to be nec-



The Blue Steel proposal of July 1960

The comparative impracticability of the carriage of a Blue Steel by TSR.2 can be seen in this illustration. Carriage of a single missile on the fuselage centreline above the fuselage would involve extensive and costly structural modifications. Carriage below the fuselage would interfere with the aircraft Doppler which was an essential part of TSR.2s navigation equipment whilst there would also be insufficient ground clearance.

essary to investigate these problems, but it was considered that of the three possible solutions, this was the least attractive.

The over-wing position had less aerodynamic objection than the under-wing position and had the added benefits that in this position, the star tracker could be used, the missile did not need modifying and the aircraft Doppler was not obscured. That said however, there were objections due to fin buffeting and shielding along with longitudinal and lateral instability. Once again, wind tunnel tests would be required before it could be determined exactly how severe these problems would be.

Of the three possible methods of installing Skybolt on TSR.2, the over-wing method was considered to offer the most plausible solution, but substantial structural modification would be needed especially to the fin which would lead to delivery being delayed and substantially increased costs. There would also be a number of operational problems. The first would be physically loading the missiles onto the top of the aircraft. The second involved launching the missile. If any attempt was made to utilise TSR.2's low altitude capabilities, in order to launch the missiles the aircraft would first of all have to enter a shallow climb, rolling through 180 degrees over onto its back in the process in order to ensure missile separation. Whilst this was not impossible to accomplish, the whole technique would depend upon the ability of Skybolt's guidance system to remain unfazed by such a manoeuvre. An alternative method of employing TSR.2 with Skybolt mounted on top would be to forget any idea of operating the system at low altitude and opt for medium-altitude release instead which would merely involve the aircraft rolling over onto its back to launch the missile.

Flying at medium altitude (about 25,000 ft) during the early part of the sortie until enemy radar coverage was reached followed by a low-level launch would only add about 100 nautical miles (nm) to the TSR.2's 1,000nm radius of action making a total of 1,100nm which was about 500nm less than would be needed to both start from and return to the UK. At the time of weapon launch, some increase in altitude above the very low level (200-300 ft) at which the TSR.2 would be flying would be necessary which would increase the vulnerability of the aircraft.

If, in spite of the increase in vulnerability, a climb to somewhere in the region of 40,000ft could be made before releasing the weapon, the range of Skybolt could be increased to about 800nm and the total radius of action would be about 1,600nm which would be sufficient to allow the TSR.2 to both start from and return to the UK. Since the climb to 40,000ft would take only 2 to 3 minutes, it was thought that the increase in vulnerability might not be significant.

Even if implemented however, the TSR.2 and Skybolt combination would do nothing to diversify the deterrent and would be inferior in almost every respect to the existing V-Bombers and emerging proposals for specialist Skybolt carriers such as the Avro Vulcan phase 6 which would possibly have been the Vulcan B.3, Avro 766 which was a version of the Trident airliner, and Vickers VC10.

Blue Steel was Britain's only 'Stand-off' Nuclear weapon. It would probably have been too big to be carried by TSR.2

Blue Steel

Blue Steel was perhaps an even more implausible proposition for mounting on TSR.2 than Skybolt. Blue Steel could not be mounted under the fuselage because in this position it would, like Skybolt, interfere with the aircraft Doppler. In addition, practical clearances could not be obtained between the aircraft and weapon and the weapon and the ground.

Mounting Blue Steel on top of TSR.2 would involve extensive and costly structural modifications and pose a difficult ground handling problem, not least due to the size and 20,000lb weight of the weapon. Even if these modifications were made, the performance of the aircraft would suffer with its range being much reduced and it was thought that landing with the weapon on board might prove impossible. If these problems were not enough, the Blue Steel had not been designed to navigate at low level and thus could not fly close enough to the ground to decrease its vulnerability.

The ballistic weapons proposed by Vickers

Vickers had carried out a brief investigation into the problem of finding a suitable propelled weapon and produced three paper versions of a ballistic missile. The first gave a range of about 20 nm at a weight of 2,500lb, the second gave a 350nm range at a weight of 7,250lb and the third a range of 700nm at a weight of 10,000lb. All these designs were to carry a half megaton warhead and navigate by a simple inertial guidance system. This type of guidance would not prove very accurate, at best giving three and a half miles Circular Error Probability (CEP) at a range of 350nm.

In the light of this it was concluded that if a new design of strategic missile for TSR.2 were to go ahead a range of between 100 and 200nm. with a terminal accuracy of between 1 and 2nm. should be aimed at. This, it was thought, would make the weapon smaller and thus somewhat easier to mount on the TSR.2.

As many of the components already developed for Blue Water as possible were to be used such as the inertial navigation system and possibly a developed form of the motor, but the missile was to be entirely ballistic with a new structure which did not utilise Blue Water's wings.

It was proposed to carry the weapon below the fuselage with extra fuel in the weapons bay and two 450 gallon fuel tanks on the wings. Vickers were of the opinion that when the aircraft was flying at not more than 500ft the weapon could be launched from underneath by first putting the aircraft into a shallow climb of perhaps five degrees.

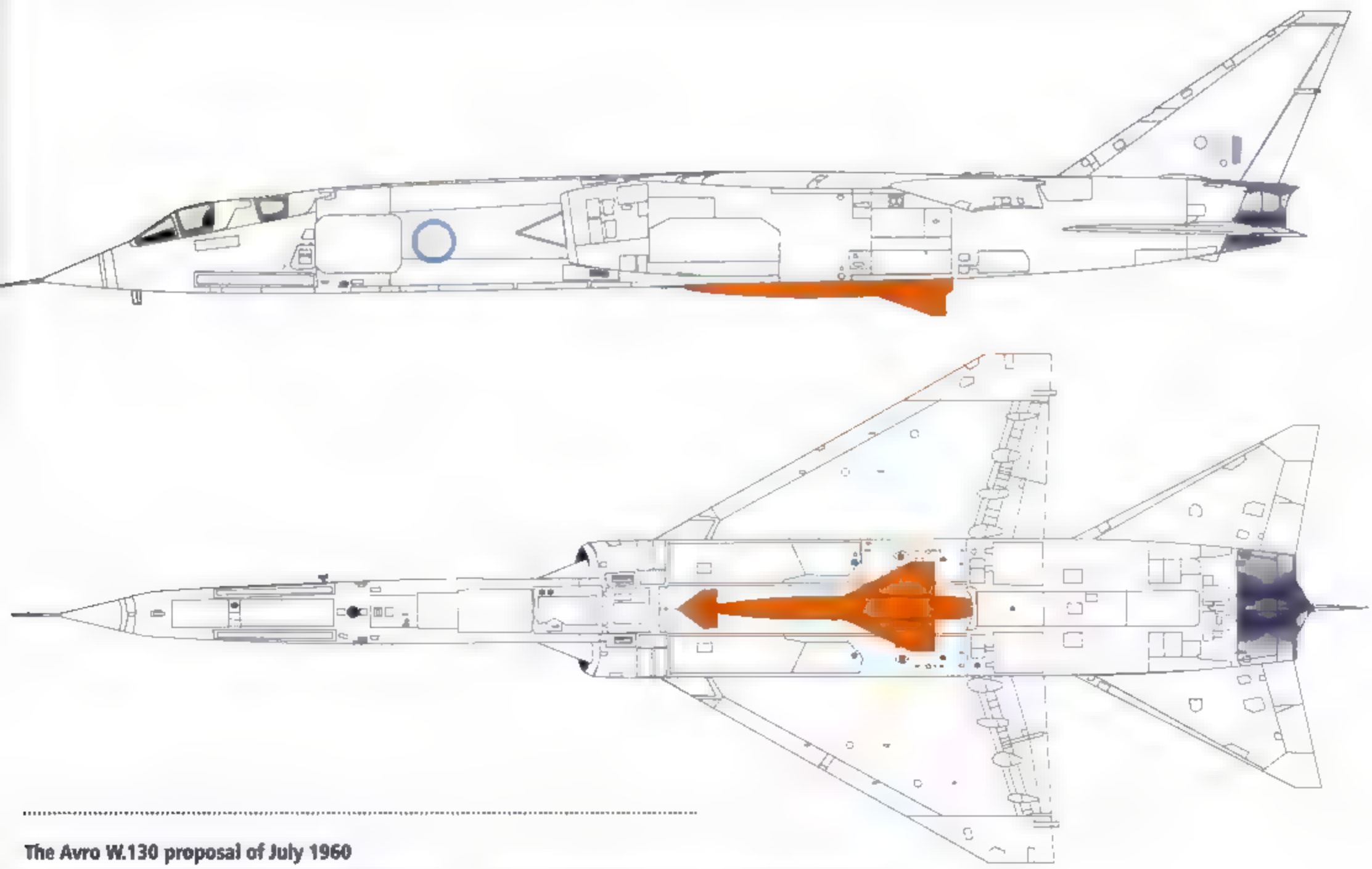
As will be seen below, this concept underwent some modification when BAC proposed the use of a modified Blue Water as well as a new ballistic missile.

Scaled-down Blue Steel

This is thought to have been a reference to the Avro W.130 which was originally designed to meet Operational Requirement 1182. OR 1182 was first raised circa 1960 for a long-range stand-off cruise type weapon to be carried by the V-Bombers in the Strategic Nuclear Deterrent role to supplement or replace Skybolt. There were two submissions to this OR, one by Bristol Aircraft Ltd called the X.12 and one by Avro which was called the W.130. Whilst the Bristol submission looked every inch a strategic weapon and will be described in some detail in a later chapter, the Avro proposal was described by the manufacturer as a complex of offensive weapons systems for both deterrent and tactical use, all of which were built around a single basic missile design.

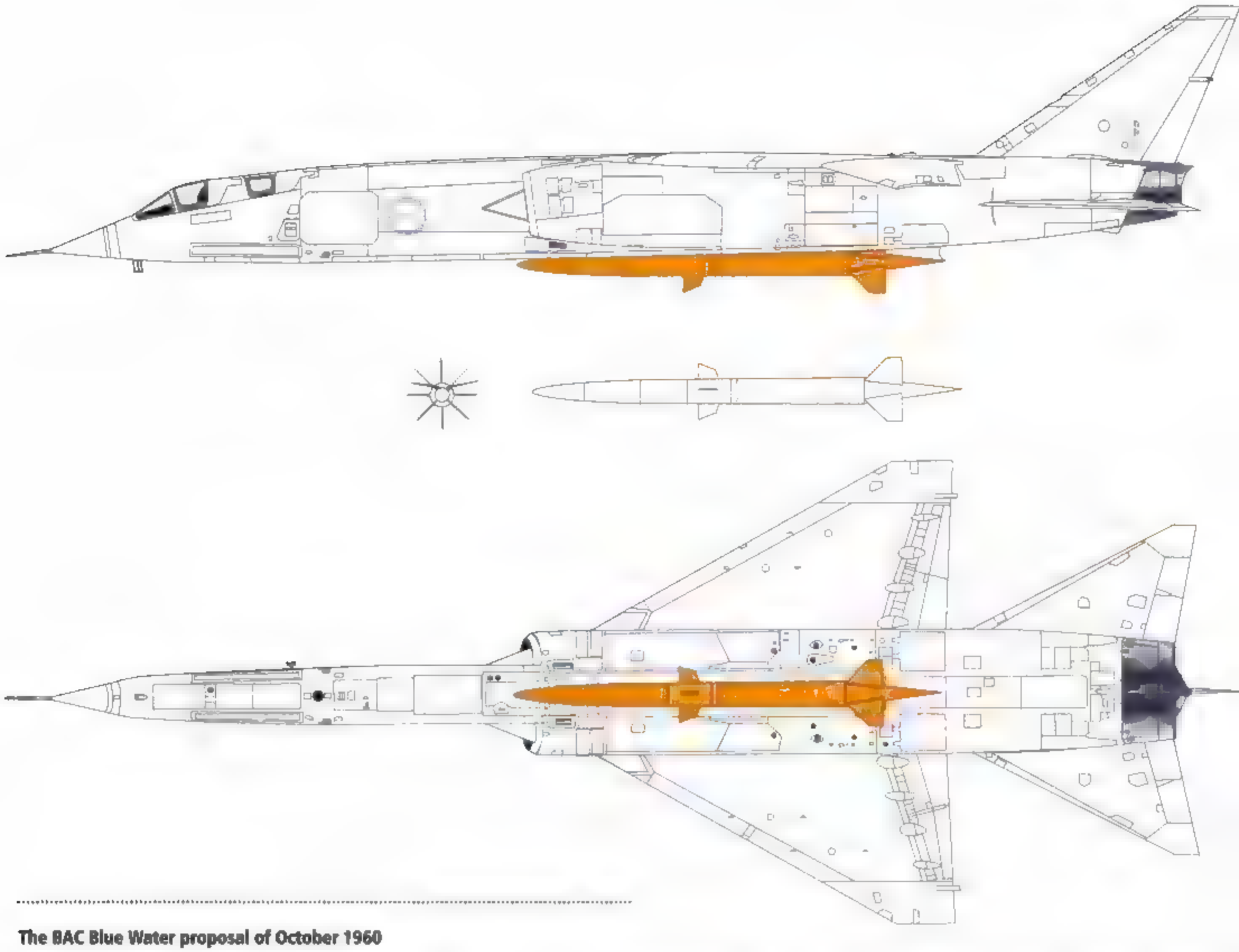
The basic missile was essentially a scaled-down version of Blue Steel stated to be 20ft long with a 7.5ft wing span weighing approximately 4,500lb. It could be launched as a single-stage tactical missile from aircraft such as TSR.2, NA 39 (which became the Buccaneer) and the Mirage IV. Alternatively, with suitable boosters it could be launched at long range from aircraft such as the Vulcan or even from a ground vehicle. It was claimed that the missile could be programmed to fly highly variable trajectories in both plan and altitude to defeat various defensive systems.

The memo summed up by stating that following this superficial examination of the problem, it appeared that carriage on TSR.2 of



The Avro W.130 proposal of July 1960

The Avro W.130 was essentially a scaled down version of Blue Steel with a length of 20 ft and a span of 7 ft 6 in which weighed approximately 4,500 lb. It was envisaged that in this form it could be launched as a single stage tactical missile from aircraft such as TSR.2, the Buccaneer and Mirage IV. It is shown here being carried semi recessed into TSR.2s weapons bay.



The BAC Blue Water proposal of October 1960

Blue Water was originally designed as a tactical surface to surface missile capable of carrying a nuclear warhead for the British Army but during 1960 BAC suggested that modifying it for air launch from TSR.2 would be a viable proposition. As the weapon was to be carried partially submerged in the weapons bay, this necessitated some modification to two of the rear fins of the missile which had to be hinged in such a manner that they were able to conform to the shape of lower fuselage of the aircraft. The nose of the missile had to be shortened by 7 in and the barometric probe removed so that it did not interfere with the aircraft Doppler whilst the wingspan was reduced by 14 in to provide the necessary clearance for the aircraft undercarriage during retraction..

Modifications to the aircraft included the provision of a weapons bay fuel tank into which a slot was let to accommodate the vertically upright forward fin, and a recess to accommodate part of the missile body and the aerodynamic fairing to accommodate the rear of the missile as shown here.

Length (not including aerodynamic fairing) 314.5 in. Diameter of body 24 in. Span of rear fins 70.4 in. Span of forward fins 67.0 in.

existing, or near existing weapons such as the Blue Steel and Skybolt, did not appear to be practicable.

A ballistic missile of between 100 and 200nm range carried externally underneath TSR.2 appeared to be one possible solution whilst Vickers had also shown that a ballistic missile of 20nm range could be accommodated in the weapons bay, and it was considered that discarding this idea might be premature.

Low-level winged weapons of about 20nm range or greater could also be accommodated in the weapons bay and such weapons would have the merit of presenting a problem to the defences in addition to that posed by Skybolt.

In conclusion it was considered that the whole picture of various stand-off weapons required more study.

No sooner had the Ministry of Aviation completed their analysis of the question of providing TSR.2 with a strategic deterrent capability than the politicians began to get in on the act. At a meeting on 28 July 1960, the Minister of Defence asked the Ministry of Aviation and Air Ministry to undertake a number of studies into the possibility of using TSR.2 to make a contribution to Britain's strategic nuclear deterrent.

As a result of this request, the Ministry of Aviation invited the RAE to examine the question of providing a Strategic Deterrent Weapon System for TSR.2 at a meeting on 16 August 1960 which reported back in November. This report will be described below. In the meantime, the Air Ministry would appear to have advocated the use of the free-falling nuclear weapons which would be provided for use by TSR.2 in the Tactical Strike role and this, along with the Ministry of Aviation study outlined above, formed the basis of a reply to the Minister of Defence's request for studies into the possibility of using TSR.2 in a strategic role dated 7 September 1960.

On 7 September 1960 the Minister of Defence was provided with a summary of the studies and the conclusions which the Ministry of Aviation and the Air Ministry had drawn from them. It was stated that the following conclusions had emerged:

a) The TSR.2 carrying a free falling weapon would be able to pose a significant low-level nuclear threat to the Soviet Union.
b) In this role it would pose a complex additional defensive problem to the enemy and would diversify the deterrent. In addition to this, it would be capable of operating from many more airfields than those used by the V-Bombers and would thereby increase Britain's immunity from surprise attack.
c) The value of the contribution to the deterrent made by the TSR.2 would be increased by the development of a stand-off weapon, but the development of the cheapest practical weapon according to the estimates prepared by the Ministry of

Aviation would cost more than £60 million.

Thus the TSR.2 with a free-falling bomb could make a valuable contribution to the deterrent. Equipped with a suitable stand-off weapon it would be still more effective but it was not known whether, on the basis of the current estimate, this would justify the cost.

Since in Europe the TSR.2 squadrons would be assigned to SACEUR for tactical operations their contribution to the deterrent either with or without the stand-off weapon would be a bonus, the value of which lay in the diversification of the threat to the Soviets.

To achieve this diversity, taking the then-current plans for Skybolt into account, it would be sufficient for the TSR.2 to rely on the kiloton weapons with which they would be provided for tactical purposes. This would avoid any additional expenditure.

It would appear that it was on the strength of this reasoning that when the Defence Committee endorsed the need to develop TSR.2 for the RAF in September 1960, they did so as the tactical aircraft it was originally intended to be. This was far from being the end of the matter however as during August and September 1960 BAC had been following up on the Ministry of Aviation's conclusion that the question of stand-off weapons required further study.

BAC proposals for a strategic capability

As a result of this follow-up work, BAC submitted a brochure entitled 'A study of the use of the TSR.2 in the overload condition to fulfil other roles' during October 1960.

In the introduction the brochure stated that the STOL characteristics of TSR.2 when operated in its normal TSR roles at a weight of approximately 88,500lb together with its supersonic performance at altitude made it an attractive proposition for overloading to an all-up weight of 120,000lb when operated from a Class 1 bomber airfield such as those used by the V-Bombers.

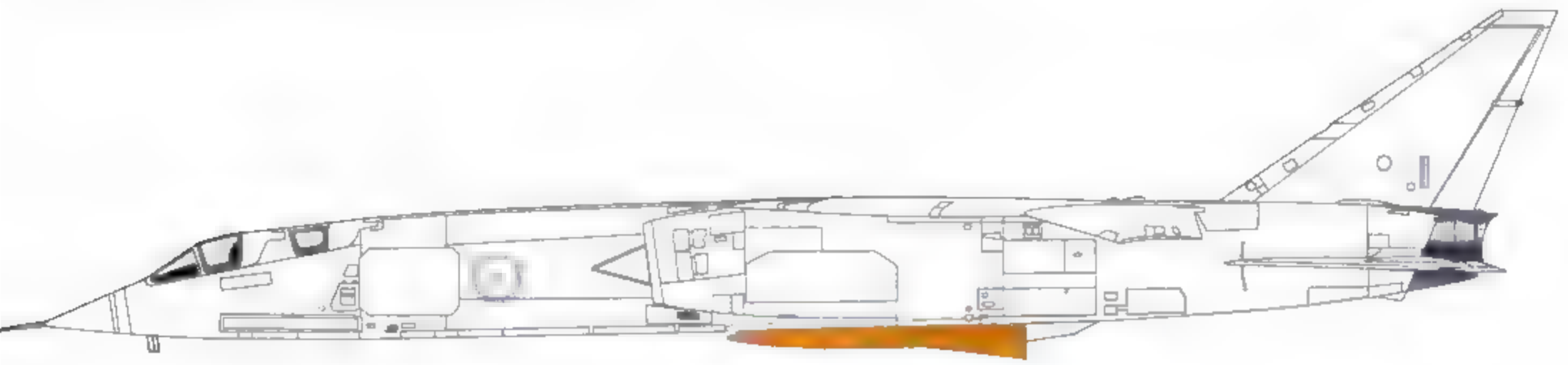
It was suggested that this load could take the form of fuel and weapons in varying proportions which might therefore extend the radius of action of the aircraft depending upon the range of the weapon carried and the altitude at which the sortie took place.

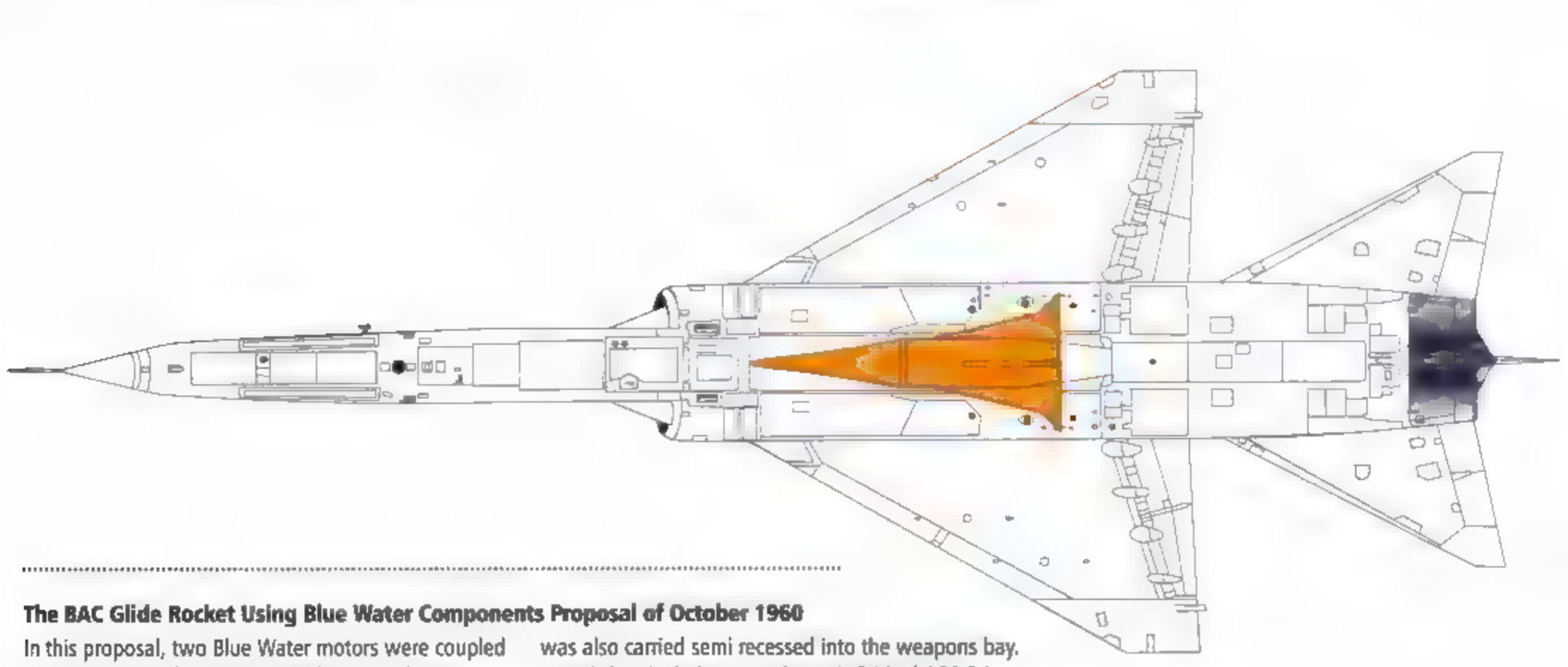
BAC had studied a number of alternative weapons which might be used by the aircraft in such a role which would be capable of delivering a nuclear weapon 2,000nm from base under the best operating conditions or 1,000nm at the worst. These were:

a) A free-falling nuclear bomb
b) A Blue Water missile adapted for air carriage and delivery with minimum modification.
c) A weapon derived from Blue Water which used the maximum number of Blue Water components but which had a longer range.
d) A ballistic missile using currently available techniques.
e) Various ramjet weapons

The free-falling bomb

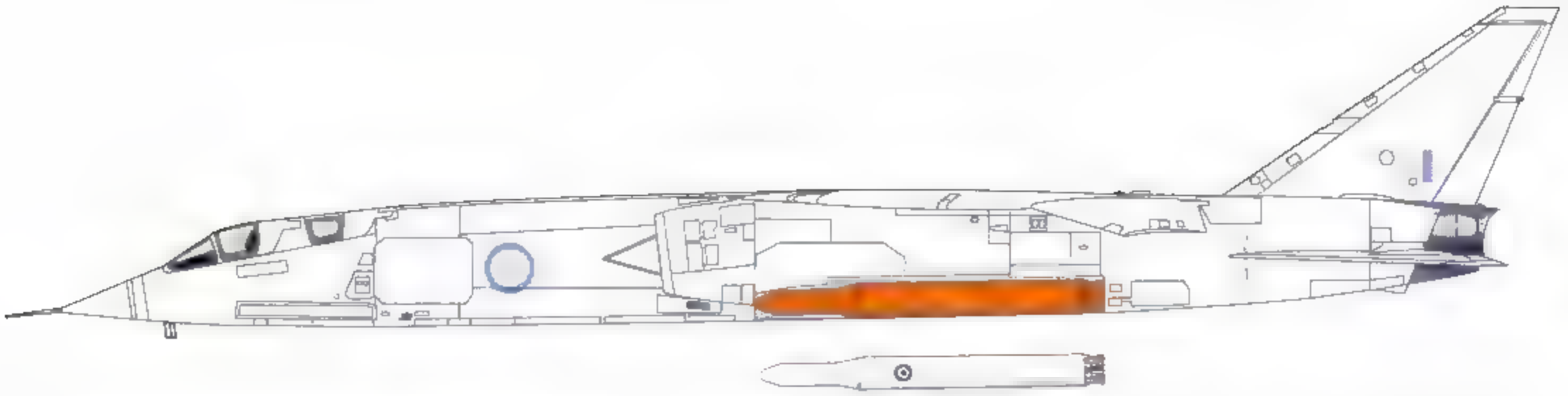
By carrying the standard under-wing drop tanks and a slipper tank under the fuselage it was thought that TSR.2 would be able to deliver a free-falling bomb 1,800nm from base when using a Class 1 airfield, returning to that same airfield following a high level delivery. Using a low level laydown delivery which entailed flying 200nm in and out from the target at low level, the strike radius would be 1,600nm.





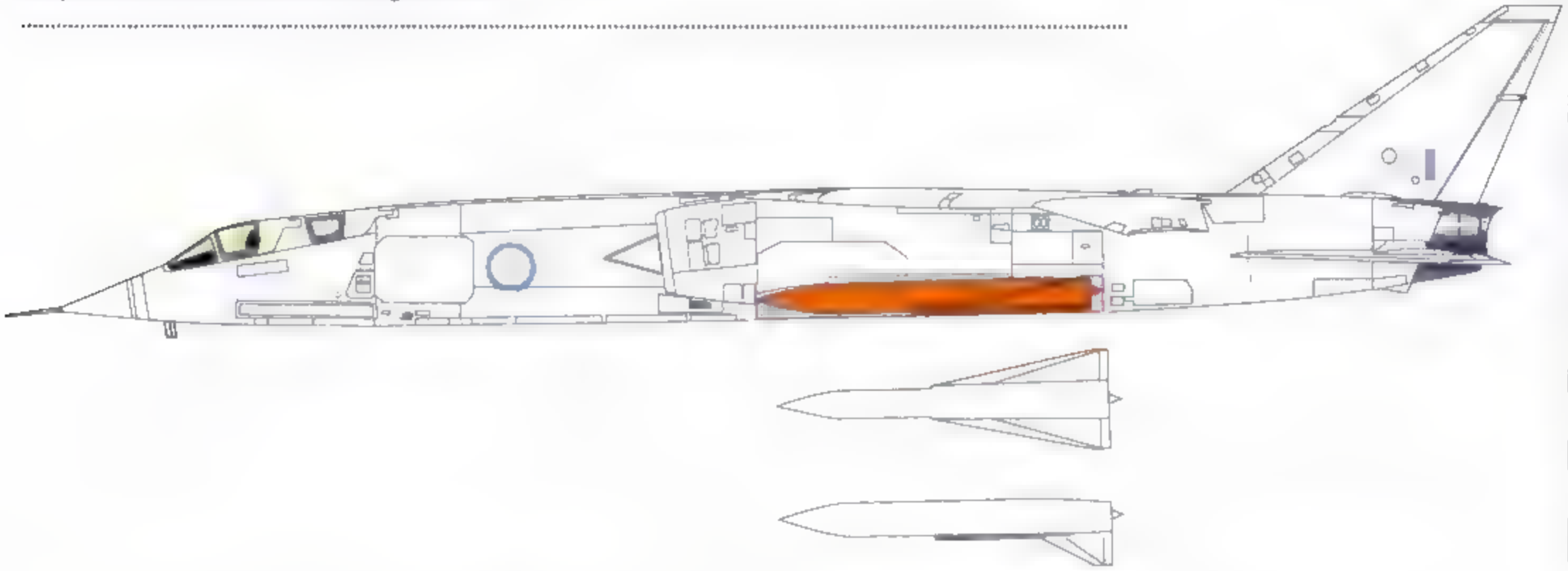
The BAC Glide Rocket Using Blue Water Components Proposal of October 1960

In this proposal, two Blue Water motors were coupled side by side in a fixed wing missile to give better lift/drag characteristics. Like the Blue Water installation proposed at the same time, this missile was also carried semi recessed into the weapons bay. Length (not including aerodynamic fairing) 278.5 in Span 148 in.



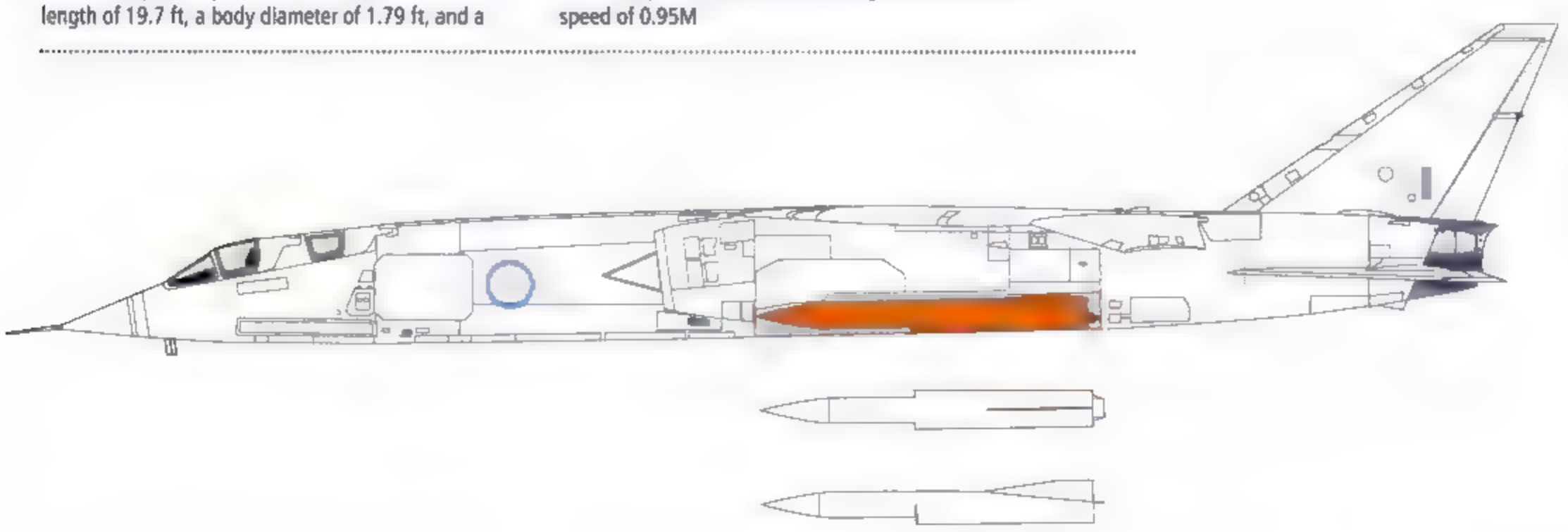
26 in Diameter Ballistic Missile Proposal of October 1960

This BAC proposal appears to have been inspired by a Vickers proposal to carry an air launched ballistic missile entirely within TSR.2s weapons bay. The weapon illustrated here has an overall length of 235 in, a maximum diameter of 26 in and a nose diameter of 18 in. It was to have carried a single Polaris type warhead.



RAE TN 675 Single Jet Engine Subsonic Strategic Missile Proposal of November 1960

The first of three proposals made by the RAE for a strategic missile which could be carried entirely within TSR.2s weapons bay the weapon shown here had a length of 19.7 ft, a body diameter of 1.79 ft, and a span with the wings deployed of 6 ft. Weighing 2,970lb it was expected to be capable of delivering a 500 KT Skybolt warhead over a range of 225 nm at a speed of 0.95M



RAE TN 675 Twin Jet Supersonic Lifting Body Strategic Missile Proposal of November 1960

The second of the three proposals put forward by the RAE for a strategic missile which could be carried entirely within TSR.2s weapons bay was for a twin jet supersonic lifting body missile as shown here. It was to have had a length of 19.7 ft a forward body diameter of 1.79 ft and a rear body width of 2.65 ft. Weighing 3,100lb it would have been capable of delivering the 300 KT warhead being developed for the WE 177 over range of 140nm and a speed of M=1.2

In each instance the cruise would be subsonic at medium altitude and the take-off run 1,500 yards. No illustration was provided in the brochure so it is not clear exactly what type of free-falling bomb was intended in this role. At this time it would almost certainly have been the original kiloton-yield WE 177.

Blue Water with minimum modification

Originally known as Red Rose, the development contract for what became known as Blue Water was placed in 1958 by the Ministry of Supply. The Blue Water missile system was a surface-to-surface tactical guided weapon capable of delivering a nuclear warhead which was under development by BAC in conjunction with the War Office, and what by this time had become the Ministry of Aviation, with the intention of replacing the British Army's existing Corporal missile system in service from circa 1964.

The weapon had to be air transportable, have the off-road capability of a three-ton truck and to have a rapid reaction time allowing it to 'shoot and scoot' with a range of between 10 and 75 statute miles.

Weighing approximately 5,000lb Blue Water was well within the TSR.2's payload capacity and in this initial design study was to be carried partially submerged within a new bomb bay fuel tank in a similar manner to that adopted by the Blue Steel in the Vulcan and Victor. This proposal appears to have been considered in very much more detail than the other proposals and was the subject of a brochure in its own right issued in March 1962 which it will be convenient to describe here.

BAC brochure 'Blue Water with the TSR.2 Aircraft'

The brochure opened with an introduction making the point that when TSR.2 went into service with the RAF it would represent a considerable investment in capital, material and engineering effort. Therefore, to extract value for money from this investment, the aircraft must have as wide an operational role as possible and its chosen targets in any particular role must be of sufficient importance to warrant the risk to the aircraft in attacking them.

The long-range high-speed low-level capability of TSR.2 together with its ability to be overloaded suggested that it might have a very useful role as a medium-range strategic bomber delivering nuclear weapons. In this role, it would both augment and diversify the overall deterrent at present provided by high-level bombers and strategic missiles.

For the purposes of the brochure, the tactical role which was the main role of the TSR.2 was ignored as the aim was to show how the TSR.2 could be used in a strategic nuclear role in the most economic manner.

Enemy defences

In considering strategic targets which might be suitable for attack by TSR.2 it was stated that:

a) Only important vital targets should be considered.
b) It must be shown to be more economical to attack this type of target with the TSR.2 than with any other form of weapon system.
c) Because the target was vital and important, it would be well defended.

To employ more firepower than was strictly necessary to destroy a major target incurred two problems, the first that it was a waste of resources which might be better employed elsewhere, and the second was that it would generate additional residual fallout.

It was therefore suggested that for medium-range small, vital and heavily defended strategic targets, a weapon was required with a modest yield but which was capable of achieving the range and accuracy required to penetrate the defences and destroy the target.

On first examination it appeared that TSR.2 could carry out such an attack using similar tactics to those used in the tactical role which involved the delivery of a free-falling bomb by a LABS manoeuvre. This was considered to be a reasonable assumption for large strategic targets but not small ones as the smaller targets were much easier to defend against attack, including those carried out at low level.

This very low-level defence was seen as being provided by Surface-to-Air Guided Weapon (SAGW) systems which it was thought would render the delivery of free-falling nuclear weapons by LABS against strategic targets impractical and it was suggested that something better was required. The suggestion put forward was that TSR.2 required a stand-off weapon which had a range of between 60 and 70nm which would allow the TSR.2 to penetrate enemy airspace at low level, perhaps climb slightly to deploy the weapon and then return to low-level flight whist staying outside the enemy's defensive bubble.

It was postulated that to develop a brand new weapon system for this purpose would be ideal, but it was recognised that this would involve a completely new Research and Development programme and that at that time, the government were highly unlikely to sanction such a project. An alternative solution was to examine existing projects to see if they could be adapted for use on TSR.2. Experience had shown that no adaptation was as straightforward as it sometimes appeared and it should be recognised that any adaptation would entail some research and development. However, this effort would not be of the same scale as that for developing a completely new project. The weapon selected as the most promising for this study was the English Electric Blue Water surface-to-surface guided missile, the background to which has already been described above.

The Air-to-Surface Blue Water System

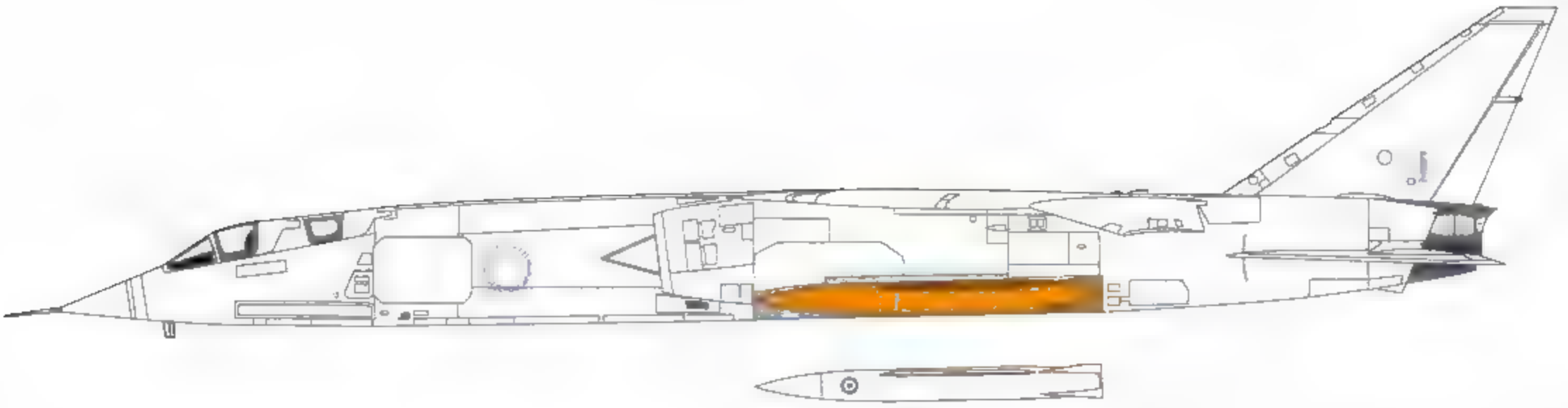
The system was based on the principle of reducing modifications to both aircraft and missile to a minimum, which had been achieved by retaining a simple and effective missile system and a maximum range from missile launch of 90 statute miles (SM.) with a CEP of approximately 2,200ft. The nuclear warhead was assumed to be of the same type as that fitted to the surface-to-surface Blue Water system. The readiness time on the ground would not exceed 5 minutes and it was thought that it might be possible to reduce this to the 30 seconds readiness time of the aircraft. Each TSR.2 was to carry one missile in a semi-recessed position under the fuselage.

The method of operation was described as being simple with a reasonable amount of flexibility. In attacking a strategic target it was thought that there would be sufficient time to prepare a detailed plan of attack which meant that it would be acceptable to programme the necessary target co-ordinates and navigation factors into the TSR.2's navigation and attack system and the missile before the aircraft left the ground. This would leave the aircrew with only minor corrections to make in the air just prior to the attack. These adjustments might only need to be made if, for instance, the pilot decided for tactical reasons to make the attack from a different bearing to that in the original plan.

The attack was to be carried out by flying the TSR.2 at low level until reaching a predetermined distance from the target. At this point, the aircraft systems automatically prepared the missile, pulled the aircraft up into a climb and released the missile. The aircraft then turned away from the target and descended back to low level for the return flight.

Installation

The physical limitations on the mounting position underneath the fuselage were the location of the aircraft Doppler beam forward of the weapons bay, the tail-down ground line at the rear of the aircraft during take-off and landing and the retraction path of the un-



RAE TN 675 Rocket Propelled Strategic Missile Proposal of November 1960

The final RAE proposal was for a missile powered by a solid propellant rocket motor of 3,000lb thrust 19.7 ft long with a body diameter of 1.79 ft and a span across the fins of 2.6 ft. Weighing 2,860lb this missile had the shortest range of all at 38 nm but the highest speed at M=2.0. It was expected to carry the 300 KT warhead being developed for the WE 177.

dercarriage. It was also necessary that the centre of gravity (CG) of the missile should lie near that of the aircraft to avoid trim problems on weapon release, and it was desirable that the strong rings in the missile structure should coincide with the front and rear weapons bay bulkheads in order to provide a reasonable base for the alignment spigots.

These requirements were met by placing the CG of the missile at Station 614 on the aircraft, shortening the nose of the missile by 7 inches and removing the barometric probe so that it did not obscure the Doppler, whilst the wingspan was reduced by 14 inches to provide clearance for the aircraft undercarriage during retraction. Even with this modification to the wings of the missile, they still slightly fouled the forward inboard doors as they closed. It was therefore proposed that a small section be removed from the forward inboard door and added to the leg door.

The body of the missile was allowed to penetrate the fuselage by an amount which did not affect any major structure and this partly-buried installation was expected to reduce drag and the level of buffeting to a greater extent than a tangentially mounted missile. It was noted that it might also prove necessary to fair the rear of the missile into the lines of the aircraft as shown in the illustrations to improve the aerodynamic characteristics.

This partially-buried installation necessitated folding the upper fins through 35 degrees before launch. Two methods of actuation for these fins were considered, either a hydraulic jack fed from a high pressure accumulator or an explosively operated jack. Whilst the latter was thought to provide the better solution, it was recognised that it would require more development. The proposed fin hinge line would be parallel to the missile axis although a skew hinge could be incorporated if slight incidence on the fins in the folded position would be beneficial during flight whilst still attached to the aircraft. A fairing was to be incorporated between the base of the folding fins and the tailcone to cover the hinge and actuation mechanism, though the uppermost wing was to be accommodated without modification inside a slot in the new weapons bay overload fuel tank.

The missile was to be mounted in a groove on the underside of a new weapons bay overload fuel tank which was hung from the bomb carrier clip positions. Incorporated into this tank were the ejector release units which would be required to pitch the missile nose down relative to the aircraft to ensure separation at launch. A slot and ducts were required in the tank for the upper missile wing and any necessary services. The pickups for the missile took the form of two spigots, one at each end of the weapon bay, which would ensure that the missile remained aligned in azimuth relative to the aircraft.

The tail of the missile was to carry a conical fairing to improve the aerodynamic characteristics of the missile whilst installed on the aircraft. This fairing could be released by a catch operated by the fin actuation or alternatively blown off by the motor efflux. The rocket motor was to ignite after release from the aircraft and there were expected to be no effects on the aircraft structure from the efflux.

The resulting projectile trajectory would give the missile a range of between 80 and 100nm reaching an altitude of 70,000ft and a speed of Mach 3. When fitted with two standard 450 gallon drop tanks under the wings and a new bomb bay fuel tank shaped to fit around the missile, it was thought that the TSR.2/single Blue Water combination would achieve a total strike radius of 1,485nm.

Timescale and cost

The modifications the brochure described were fairly numerous but of a minor nature. It was thought that if a start were made on the project by the middle of 1962 then the preliminary work on the missile, aircraft and ground equipment would probably have been done well before TSR.2 was available to carry out flight trials from 1964. Flight trials were expected to consist of 50 hours of carriage and jettison trials with dummy missiles and non-flight rounds, and 25 hours of firing trials with 12 missile launchings. These trials would probably run well into 1965 and would be followed by acceptance trials towards the end of that year.

Excluding the support equipment carried by the aircraft, the cost was expected to be about £300,000. This sum was to cover design of the new overload fuel tank in the weapons bay and development on the installation aerodynamic and release aspects. The cost of the missile development was set at between £4 million and £5 million. The total figure was therefore £5 million or slightly over with an in-service date of late 1965.

Modified version of Blue Water

Returning now to the original 1960 study of the use of the TSR.2 in the overload condition, the modified version of Blue Water illustrated in the brochure utilised a new arrangement of existing Blue Water components. Two Blue Water motors were coupled side-by-side in a fixed wing missile to give better lift/drag characteristics. Like the Blue Water installation described previously, modified Blue Water was to be semi-recessed into the weapons bay and launched from a toss attack.

Guided by identical systems to those of the original Blue Water design, the modified missile once released was expected to attain a maximum altitude of approximately 100,000ft with a 200nm range. The radius of action of TSR.2 fitted with this weapon was considered to be in the region of 1,540nm where the aircraft cruised at medium altitude for 1,140nm and then flew at low altitude for 200nm prior to release of the missile which then flew the terminal 200nm.

Ballistic missiles (separate re-entry head)

The fourth BAC proposal appears to have been inspired by the Vickers concept referred to previously in that it was an air-launched ballistic missile which was carried entirely within TSR.2's weapons bay. This was by far the most ambitious of BAC's proposals but it is possible that had such a course been chosen that Britain could have developed its own air-launched ballistic missile without relying on American technology, as there was an extensive body of knowledge and expertise available in British industry.

At about the same time that work began on Blue Streak, in May 1955 the Guided Weapons Department of the RAE outlined a specification for a rocket which could be used to test different types of warheads which could be fitted to Blue Streak or indeed any other ballistic missiles which might be developed by the UK. Saunders Roe was awarded the contract for the structure of what became known as Black Knight whilst Armstrong Siddeley was to be responsible for developing the propulsion system. An engine test site for Black Knight was built at Highdown on the Isle of Wight overlooking the Needles where Black Knight's hydrogen peroxide and kerosene powered engine was successfully tested during 1957 with the first flight taking place from Woomera on 7 September 1958.

The RAE also conceived and promoted a third type of rocket powered by a solid propellant intended to propel small packets of scientific instruments into the upper atmosphere. Developed by the Rocket Propulsion Establishment at Westcott, Skylark had flown from Woomera by February 1957. Thus by 1960 a wide range of technical knowledge and suitable research vehicles were available in Britain which could potentially be applied to the development of a ballistic missile for use with TSR.2.

The BAC brochure stated that a preliminary study of a series of new ballistic missiles had been made which were single-stage weapons carrying a Polaris re-entry head and inertial guidance system.

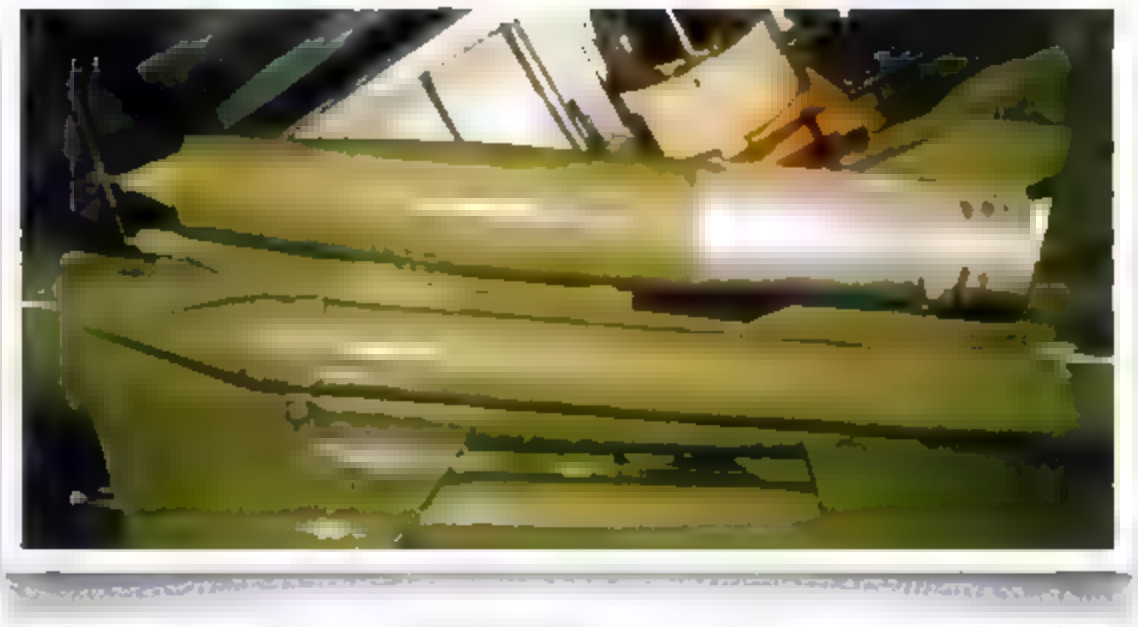
The largest missile which could possibly be accommodated within TSR.2's weapons bay was expected to give a range of 350nm when launched from low altitude. Since it was thought that at this range there would be guidance problems due to errors incurred from alignment and initial settings, it was thought that it would probably be best to use a somewhat smaller missile with a range of about 200nm. This smaller missile was illustrated in the brochure.

When loaded with this missile, a slipper tank and the standard wing tanks, TSR.2 was estimated to have a total strike radius of 1,740nm: the sortie consisted of a medium altitude cruise for 1,340nm, a low-altitude penetration of the defences for 200nm followed by a low-level release 200 nm from the target. With a high-altitude launch 300nm from the target following a cruise at medium altitude of 1,700nm, the total strike radius could be of the order of 3,000nm.

Ramjet missiles

The brochure stated that Bristol Aircraft had studied a number of missiles which would use a modified BT3 ramjet to fly all the way to the target at M=2 at about 200 ft. However, no specific details of these missiles were given other than to say that investigation of the fitting of these missiles to TSR.2 would cause problems due to their length if placed under the fuselage and whilst under-wing mounting was also being considered, various stability and alignment problems had not yet been assessed.

The ramjet proposals were still in their early stages but were considered an attractive proposition as their use would avoid any pull-up manoeuvre by the aircraft and the missile would then complete its attack on a highly invulnerable flight path. A note of caution was sounded as it was considered that the problems and cost of the development of the terrain avoidance system for this type



Developed versions of the Bristol Siddeley Thor ramjet used to power the Bloodhound Surface to Air Missile were considered for application to a 'Stand-off' weapon for TSR.2

of missile should not be underestimated. This appears to be a reference to the Bristol X.12 which was being developed to meet Operational Requirement 1182 which will be described below.

The RAE proposals of November 1960

The next set of proposals for using TSR.2 in the deterrent role received by the Ministry of Aviation were those put forward by the RAE as a result of the meeting of 16 August mentioned above in a report dated November 1960. The report was entitled 'Royal Aircraft Establishment Technical Note No. ARM. 675 Low Altitude Strategic Weapons for the TSR.2'.

This report envisaged a propelled bomb designed to fit inside the weapons bay which might enter service from about 1968. Three basic designs were suggested which were to be guided by an inertial navigation system coupled to an auto pilot and forward looking radar, with a development time of somewhere in the region of seven or eight years.

For the purposes of the design study it was assumed that the space available within the TSR.2's weapons bay would be limited to that of the current design with a length of 20ft and a cross-sectional area of approximately 3ft diameter without further modification, and that during the time that the weapon was being carried, no part of it might protrude outside this space thus preserving the full aerodynamic characteristics of the aircraft. The only characteristic of the weapon which would affect the TSR.2's performance was therefore its weight so that the aircraft would be able to penetrate long distances into enemy territory at high subsonic speeds and low altitude.

Three versions of low-altitude missiles were considered to be feasible. The first of these was a single jet engined missile with folding wings 9.7ft long, with a body diameter of 1.79ft and a wingspan with the wings unfolded of 6ft. It was powered by a single RB (93) SOAR. This weapon was to have a total weight of 2,970lb and deliver a 500 KT Skybolt warhead with a CEP of 1.3nm over a range of 225nm flying at a maximum speed of .95M at 200ft.

The second design was a twin-jet-engined lifting body 19.7ft long, with a body diameter of 1.79ft and a maximum diameter over the engines of 2.65ft powered by two RB (93) SOAR. Total weight was 3,100lb and this design was to deliver a 300 KT warhead to OR 1176 for use in the new weapon being developed to OR 1177 with a CEP of 0.5nm over a range of 140nm at a speed of M=1.2 at 200ft.

The third design was a rocket powered lifting body propelled by a solid propellant rocket motor of 3,000 lb. thrust. Once again this missile was to be 19.7 ft. long with a body diameter of 1.79 ft. but with a span across the fins of 2.6 ft. It was to weigh 2,860 lb., also delivering the OR 1176 300 KT warhead with a CEP of 0.1 nm. but this time over the much shorter range of 38 nm. at a maximum speed of about M=2. It was considered that this rocket version could be eliminated at the outset as maximum range was the primary aim of the study, but that both of the jet powered versions were worthy of further study.

It was concluded that a useful low-altitude strategic missile could be developed for stowage completely inside the bomb bay of TSR.2. It would weigh about 3,000lb and would have terrain following and inertial navigation systems, use a projected powerplant and would take between seven and eight years to develop into service.

The weapon might have folding wings and be powered by a single jet engine giving a top speed of 0.95M and a range of about 225nm carrying a 500 KT warhead and having an accuracy of about one and a quarter miles CEP. Longer ranges of up to 255nm might be possible using a smaller 300 KT warhead but accuracy would fall off at this range to about one and three quarter miles CEP which with a smaller warhead might not be acceptable. The number of strategic targets which could be reached from a 3,000 yard runway in the UK by the TSR.2 with this weapon at an overload weight of 117,000lb would amount to 52 percent of the British Nuclear Deterrent Study Group's (BNDSG) target list for the 500 KT warhead and 57 percent for the 300 KT warhead.

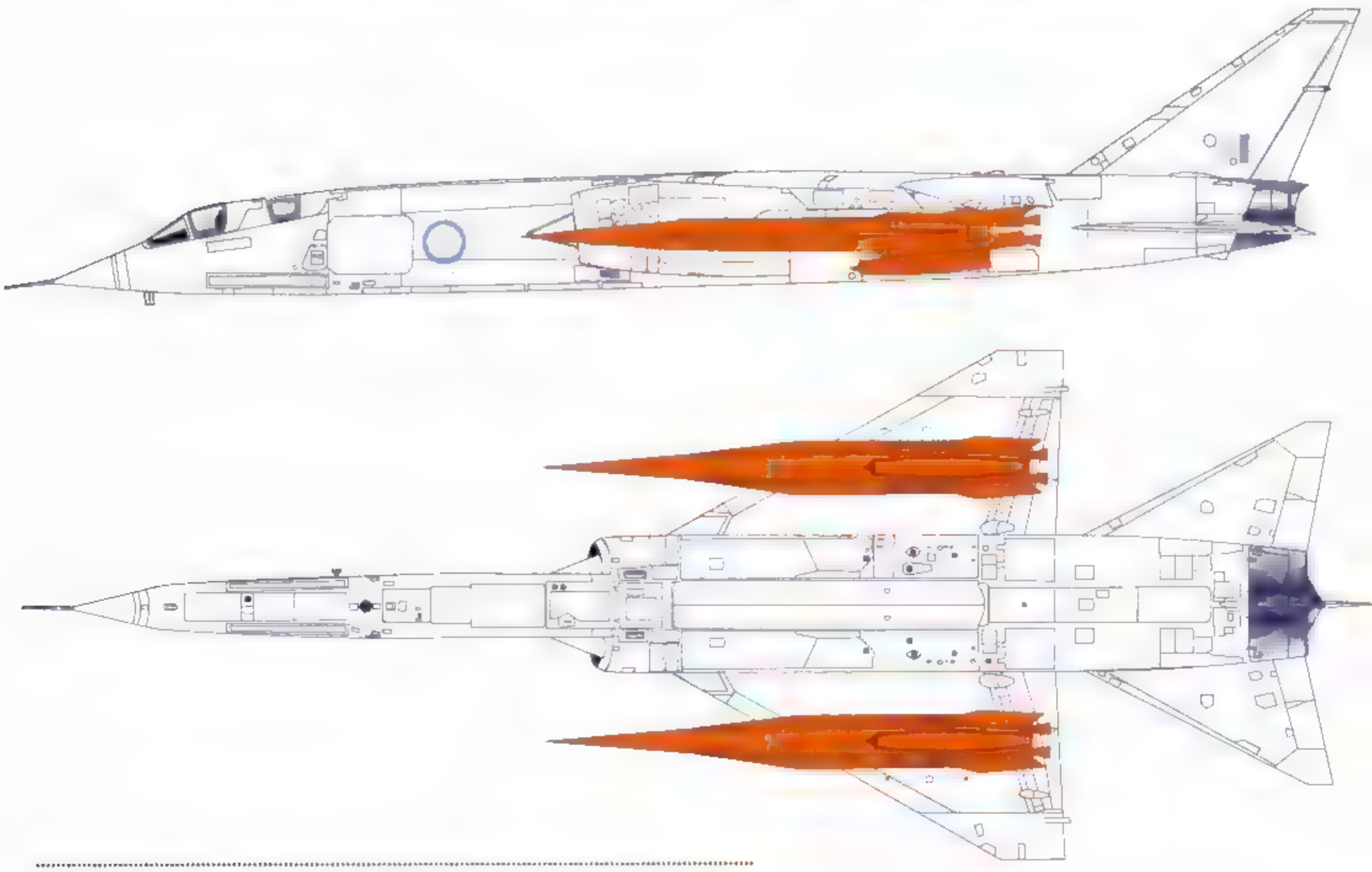
Alternatively, the weapon might be a twin-engine wingless lifting body missile with a speed of M=1.2. It would have a range of about 140nm and when carried by the TSR.2 as described above could reach about 35 percent of BNDSG targets from UK bases. This supersonic version would carry the warhead designed for the WE 177 with a yield of 300 KT which would be sufficient for deterrent purposes, in this case because of the enhanced accuracy of less than half a mile CEP which would be due to the shorter time of flight.

When operating from 1,000 yard semi-prepared airfields abroad at a reduced weight of about 85,000lb. TSR.2 with either of the weapons described above would have a greatly enhanced capability. It was expected to be capable of attacking somewhere in the region of 82 percent of the BNDSG targets with the supersonic weapon, a figure which increased to 95 percent with the subsonic weapon.

This was because the ranges involved were such that at normal take-off weights or by in-flight refuelling the TSR.2 would be able to attack all the targets by penetrating enemy airspace at low altitude to a depth of no more than 285nm using the subsonic weapon or 400nm using the supersonic weapon. With complete stand-off capability from the Iron Curtain and Soviet perimeter about 29 percent and 67 percent of the BNDSG targets could be attacked with the supersonic and subsonic missiles respectively.

Projects reviewed

All these proposals were put before the BNDSG who came to the conclusion that all the proposed stand-off weapons were ruled out either due to technical reasons or development costs and that



The X.12 Proposal

The second issue of OR 1182 for a long range stand off weapon dated 10 January 1961 stated that two weapons to this specification should be capable of being carried by TSR.2.

Bristol Aircraft Ltd produced a small brochure entitled 'Project X.12 A Ramjet Propelled Long Range Air Launched Deterrent Weapon' which suggested that two of these missiles could be carried on the underwing pylons of TSR.2.

Powered by a Bristol Siddley E 24 ramjet, the X12 was to be propelled to its operating speed by the boosters clustered around the rear of the fuselage in a similar manner to the Bloodhound Surface to Air Missile. Length without boosters 30 ft. Length with boosters 33 ft 4 in. Maximum diameter of fuselage 28 in. Span of wings 4 ft. Overall span with boosters fitted 9 ft.

TSR.2 retained a significant strategic capability with freefall or lay-down weapons and could thus be regarded as an insurance against failure of Skybolt.

However, the BNDSG recommended that that further technical studies be made of the feasibility and operational value of the long-range missile with low-level capability, the possibility of providing a short-range missile for the TSR.2 and a free-falling bomb which the TSR.2 might use in the strategic role.

These recommendations led to the reissue of OR 1182 for a long-range missile, BAC resubmitting their Blue Water proposal in March 1962 as described above and the Ministry of Aviation, Air Ministry, Ministry of Defence and Atomic Energy Authority preparing a paper on the possibility of producing a megaton laydown bomb to provide TSR.2 with a strategic capability in the period 1965–1970.

The long-range missile – OR 1182

In December 1960 a joint Air Ministry and Ministry of Aviation working party reported on the technical possibilities and operational value of a long-range air-to-ground weapon for the RAF. They concluded that by 1966, nothing better than improved versions of Blue Steel which had already been dismissed at Ministerial level could be available. It was considered that neither the Avro W.130 nor the BAC X.12 had been given sufficiently detailed consideration by the designers to allow the formulation of a sound estimate of the likelihood of either missile satisfying the Air Ministry requirement.

Therefore in January 1961 the Ministry of Defence asked that a feasibility study be initiated of a long-range cruise type weapon to OR 1182 be carried out and OR 1182 was reissued on 10 January 1961.

OR 1182 was defined as being for a stand-off weapon, primarily for use with the V-Bomber force to be in operational service by 1966.

The weapon was to have a variable trajectory, the ability to perform evasive action, to have a low-level terminal phase of flight of at least 100nm whilst following the terrain at an altitude of not more than 300ft.

The weapon was to be capable of being launched at supersonic and subsonic speeds at both high and low level. When launched from low level, the weapon would not be required to climb to high altitude before the terminal phase of the flight.

The range of the weapon from launch was to be 1,000nm with the capacity to achieve a total all low-level sortie range of not less than 200nm when launched from below 1,000ft. The aircraft and missile combination was to be capable of engaging targets up to 2,500nm from take-off with an overall accuracy no worse than two and a half miles CEP at maximum range.

The missile was to cruise at M=3 to M=4 at high level and M=2 at low level.

Up to four missiles were to be carried by Mk 2 V-Bombers and two missiles were to be carried by TSR.2.

If the entry to service date of 1966 proved impossible to meet with all the desired characteristics, then an interim version might be considered with the missile range requirement reduced to between 600 and 1,000nm with a speed of M=3 to M=4 at 70,000ft and an accuracy of 2.5nm CEP at maximum range with the low-level capability initially omitted.

Both BAC and Hawker Siddeley were asked to prepare feasibility studies of the airframes whilst Ferranti, the only firm which was knowledgeable about terrain following equipment, was relied upon to study the electronics.

The final report dated July 1961 only considered the application of the designs which emerged to OR 1182 to the Vulcan and Victor stating that in the limited time available, it had not proved possible to give serious consideration to the carriage of these missiles on TSR.2.

Any 'Stand-off' weapon would require some kind of autopilot as did TSR.2 itself

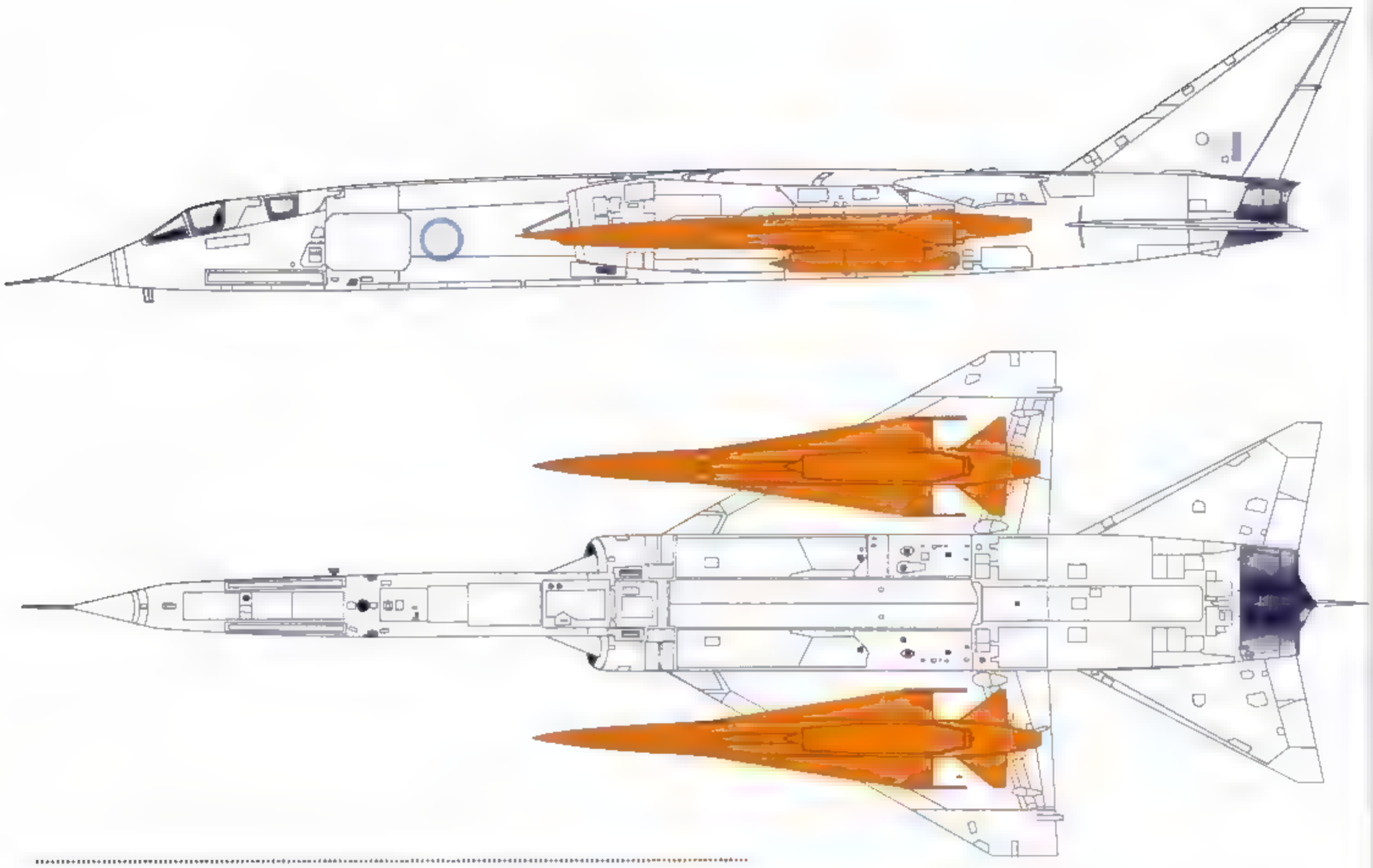
The BAC submission was a revision of the ramjet powered Bristol X.12 which had been submitted to the original issue of OR 1182. To meet this requirement, Bristol Aircraft Ltd had produced a small brochure entitled 'Project X.12 A Ramjet Propelled Long Range Air Launched Deterrent Weapon'. Apparently based upon a similar concept to the Bristol Bloodhound Surface-to-Air missile, the X.12 was essentially a ramjet powered cruise missile which was intended to be launched from either a TSR.2 at low altitudes or Vulcan B.2 at 40,000ft, whereupon the missile would descend to penetrate enemy airspace at an altitude of 200ft and speed of 0.8M. TSR.2 was illustrated as carrying two X.12s and a Vulcan up to four giving an estimated TSR.2/X 12 strike radius of 900nm. The X12 had an unboosted length of some 30ft which increased to 33ft 4 inches when boosters were fitted and a wingspan of 9ft.

In its revised form the X.12 was to be capable of a top speed of M=4 at altitude and M=2.8 at low level. Range was to be 1,030nm of which 100nm would be flown at low level. The missile weighed 15,000lb when fully loaded so two of these missiles would have been quite a load for TSR.2.

The Hawker Siddley submission was a new turbojet powered design, the Avro W.140. This was to have a range of 950nm which included 100nm at low level. The requirement for 1,000 miles range could be met provided that the low-level dash did not exceed 92nm. Top speed was to be M=3 at altitude and M=1.5 at low level. This missile weighed 8,550lb and might therefore have been a better prospect for carriage by TSR.2.

The report concluded that the BAC X.12 had sufficient range and speed to meet the requirement but its weight was a major disadvantage even for carriage on the V-Bombers which would need considerable development to be capable of carrying 2 missiles to the required range. It was thought however that a missile-carrying variant of the VC10 should be capable of carrying four missiles to the required range.

The Avro W.140 almost met the requirement but failed on several counts. Whilst meeting the high-altitude speed requirement of M=3, it failed to meet the low-level speed requirement of M=2 in having a top speed of M=1.5 and the cruising altitude was also



Avro W.140

The second weapon to emerge from the from the second issue of OR 1182 was the Avro W.140 as illustrated here. This weapons link with the TSR2 is more tenuous than that of the X.12 as other than the statement in the second issue of OR 1182 that two of the weapons designed to this specification should be capable of being carried by TSR.2 there is little evidence to suggest that the Avro W.140 was ever seriously considered as a suitable weapon for the aircraft. Length 38.2 ft. Diameter of Body 30 in. Span 6.7 ft.

less than the specified 70,000 ft. It was thought that with a twin-missile installation, a substantial radius of action would be possible with this missile mounted on a V-Bomber due to its comparatively small weight and low installed drag but even so, neither standard V-Bomber could carry four missiles to the desired radius.

Whether the required accuracy of 2.5nm CEP at 1,000nm could be achieved by either design on entering service was thought to be doubtful as it seemed likely that a suitable navigation system could not be developed in Britain in the specified timescale. Whilst such equipment could perhaps be obtained from the US, the Ministry of Aviation did not feel that they could enquire at that time.

Both types of powerplant, both the ramjet for the X.12 and the turbojet for the Avro W.140, would need extensive development and the timescale of the development of either version was not likely to be less than eight years, nor the cost likely to be less than £75 million. This development work would be at the expense of the TSR.2 project.

Having said that however, it was thought that the development of TSR.2 would provide the knowledge into many of the techniques necessary to develop such a weapon if a start were made in about five years time. The only exceptions to this would be the high-speed ramjet and the navigation system.

Following the submission of this report, the whole matter of providing TSR.2 with a stand-off nuclear capability seems to have been dropped. When BAC resubmitted their Blue Water proposal as described above in March 1962 it met with a very cool reception at the Air Ministry. An internal Air Ministry memo dated 27 April 1962 stated that the DOR did not want to bring up the various arguments about using TSR.2 as a strategic weapon again at that time. With negotiation about to start with the Treasury for the continuation of the TSR.2 programme into its next phase of 11 aircraft, it was thought to be unwise to introduce any 'red herrings' into the proceedings. As the BAC proposals stood, the DOR was of the opinion that there were quite a number of holes in the concept and were not convinced that this was the correct approach. If the TSR.2 at some later date were fitted with a stand-off weapon and was used as a complement to Skybolt to diversify the deterrent, it was thought that it would be perhaps better to use a low-level, short-range terrain-following missile. Therefore the DOR stated that it did not intend to proceed with this matter any further.

Chapter 3

Stop-gap Deterrent 1963

IN JUNE 1960 BRITAIN HAD OPTED TO COLLABORATE WITH THE US in the development of the Skybolt air-launched ballistic missile which was intended to lie at the heart of Britain's nuclear deterrent. By February 1962, British plans had advanced to the stage where Bomber Command was able to attach a trials team to Avro at Woodford where the first Vulcans were being built to carry the weapon. Following this in May 1962, a trials team was also dispatched to Eglin Air Force Base in Florida where trial launchings from Boeing B-52 and Vulcan bombers were due to take place.

The first test firing of a Skybolt took place just before the arrival of the trials team and this was followed by a second test on 29 June and further tests on 13 September, 25 September and 28 November 1962. All of these tests were only partially successful, but on the whole were no more disappointing than could perhaps be expected in the early trials of a new and complex weapon system. For example, at least three of the first six test shots of the Polaris system had also proved to be less than a total success. Nevertheless, Skybolt's perceived failings gave ammunition to those on both sides of the Atlantic who had been sceptical of the wisdom of embarking on the project in the first place.

Whilst Britain had effectively staked the future of its nuclear deterrent on Skybolt, the US had a plethora of weapons systems at its disposal, the loss of any one of which would not be critical. Indeed, the US Secretary of Defence Robert McNamara is reported to have said that Skybolt would be nice to have but was not essential. By November 1962 McNamara had stated that the development costs of Skybolt had doubled and that the US were considering alternative systems. In response, the British government warned that any threat to Skybolt could put Anglo-American relations under severe strain. Behind the scenes, there were those in Britain who saw the threatened cancellation of Skybolt as a political move by the Kennedy Administration to try to force Britain to give up its independent nuclear deterrent, though the rising cost and apparent technical failures of the project were the reasons actually cited in the American decision to cancel the project.

By early December 1962, the American criticism of Skybolt had just about been accepted by the British government who began to lobby the US for Polaris as a replacement system. The details of the resulting negotiations are too complex to discuss here, suffice to say that on 21 December 1962 following a meeting between President Kennedy and Prime Minister Macmillan at Nassau in the Bahamas, a joint US/UK press statement was issued confirming that the US would make Polaris missiles without warheads available for British submarines that could be used independently 'when supreme national interests were at stake'. This wording was deliberately ambiguous so as to allow Macmillan to claim that he had preserved Britain's independent nuclear deterrent while paying lip-service to Kennedy's multilateralist policy.

Skybolt itself had the last word when a sixth test shot was made the following day. Within the parameters set for the test, it was an outstanding success with the air-launched missile travelling 900 miles down range with all its systems working satisfactorily. Had Skybolt have been allowed a full development programme it would almost certainly have been a success.

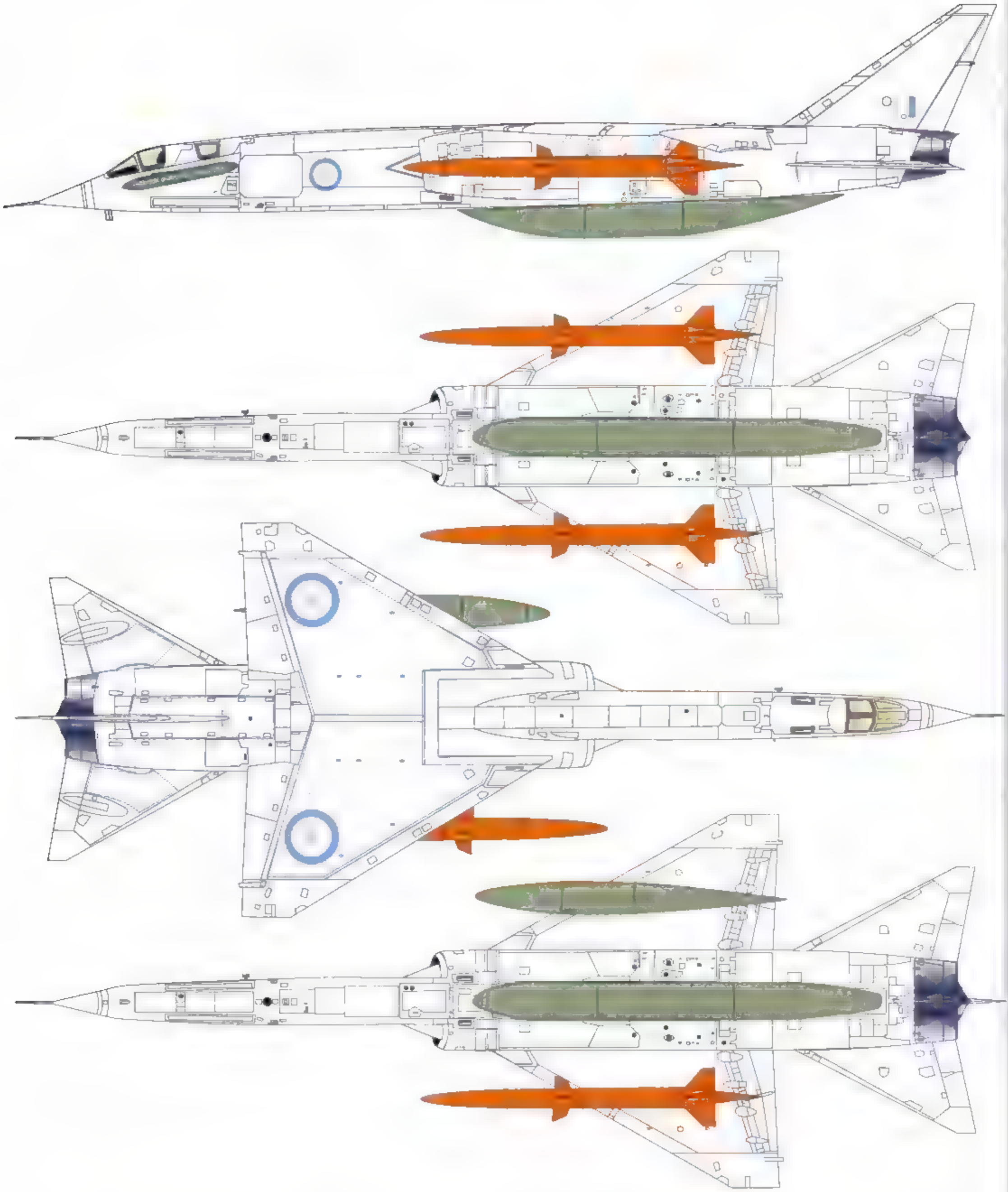
A Victor B.2R equipped with Blue Steel in low level camouflage

Militarily, the loss of Skybolt was a severe blow to both Britain and the RAF. Until such time as Polaris entered service, which was expected to be circa 1968/69, there was some question as to the effectiveness of Britain's deterrent which was carried by the V-Bombers. The doubts of its effectiveness stemmed from the advances made in the Soviet air defences which now made it questionable whether the V-Bombers would be able to reach their targets to deliver their free-fall nuclear bombs, or even get close enough to launch the Blue Steel stand-off bomb which had yet to reach operational status in any case.

As soon as Skybolt was cancelled, steps were taken to try to devise a credible stop-gap deterrent which would be effective between 1964 and circa 1969/70 when Polaris was expected to enter service. As far as the V-Bombers were concerned, the decision was taken to switch them from high to low level operation and to modify Blue Steel to allow it to be launched from and navigate to the target at low level.

Those V-Bombers which were not equipped with Blue Steel would be armed with a new high yield laydown bomb which could be delivered from low level. This weapon was a developed version

Vulcan B.2 XH534 was one of the V-Bombers only equipped to deliver free falling weapons for which the WE 177B was developed



BAC Brochure K2/132 Twin Underwing Blue Water Proposal of January 1963

BAC Brochure K2/132 entitled ' Strategic Weapon System Blue Water on V-Bomber of TSR.2' dated January 1963 proposed that two Blue Waters could be carried on the inboard stores stations under TSR.2s wings. The missile itself was 4 ft longer than the earlier version which had been proposed in 1960 and again in 1962 which allowed extra fuel to be carried thus increasing the range.

Additional electronic equipment occupying approximately 2 cubic ft would be positioned in the rear of the weapons bay, the remainder of the weapons bay being taken up with a non jettisonable fuel tank. An external ventral fuel tank was also to be carried.

In order to achieve the maximum possible range, it was suggested that a single Blue Water might be carried under one wing with a drop tank under the other wing.

of the kiloton yield bomb being developed to OR 1177 which was intended to replace the Red Beard tactical nuclear bomb.

The development of two weapons led to the original kiloton yield tactical weapon becoming designated as the WE 177A whilst the thermonuclear megaton yield version became known as the WE 177B. As the developed thermonuclear variant was needed more urgently than the original kiloton yield weapon, the WE 177B was accorded the greater priority and is thought to have entered service with the Vulcan Wing at Cottesmore in September 1966. The WE 177B then remained in service with the RAF until 1998. In contrast, the original WE 177A is not thought to have entered service until the early 1970s. The main distinguishing feature of the WE 177B when compared to the WE 177A was its greater length and two external 'cable ducts' which ran along the top of the weapon.

As the delivery of the WE 177B by the V-Bombers depended upon their surviving a trans-Russia flight at low level, the V-Bombers would also receive a low-level green and grey camouflage scheme on their upper surfaces to help them escape visual detection.

In addition to these measures to try and retain the operational effectiveness of the V-Bomber fleet, attention turned once again to using TSR.2 in the deterrent role. Between January and March 1963 a number of schemes were put forward from a number of sources as to how TSR.2 could be employed as a strategic bomber. Some of these schemes were more fully thought out than others and better documented. The descriptions which follow reflect this.

A number of Victors were converted to the Strategic Reconnaissance role. Designated Victor SR.2, these aircraft also received low level camouflage

The Blue Water was also proposed for fitting to the Vulcan using the redundant under wing strong points originally intended to carry Skybolt

Blue Water resurgent

Although Blue Water had not been selected for development in an air-to-surface role either during 1960 or in March 1962 as described previously, it was considered to be perhaps the best surface-to-surface weapons system on the Allied development list and was making good technical progress with two fully guided rounds having been fired from Aberporth when it was cancelled to save money which could then be spent on TSR.2 in August 1962 after £16.6 million had already been spent on its development.

At that time, the cancellation of Blue Water was a major blow for BAC as it was the main new project in the BAC Guided Weapons Division and as a result one of the English Electric Guided Weapons factories, Luton or Stevenage (ultimately Luton) would have to close. It is therefore not too surprising that BAC tried to keep the Blue Water project going by once again suggesting its adaptation for air launch from TSR.2, this time as a stop-gap strategic deterrent weapon following the cancellation of Skybolt.

BAC brochure K2/132 entitled 'Strategic Weapon System Blue Water on V-Bomber or TSR.2' dated January 1963 was submitted to the Ministry of Aviation along with ■ covering letter from English Electric which was dated 29 January 1963.

This brochure was split into two sections, the first of which dealt with fitting the Blue Water to a Vulcan and the second part of which dealt with fitting the Blue Water to TSR.2. The introduction to the latter section stated that TSR.2 was being developed to fulfil the RAF's requirements for tactical reconnaissance and interdiction. Its ability to fly at high speed at very low altitudes and its accurate self-contained navigation system would enable it to penetrate enemy territory in safety and to deliver its attack with great accuracy in blind conditions.

Its outstanding low-level performance made it the ideal aircraft to carry Blue Water in the strategic role, and it was now in an advanced state of development.

The comprehensive navigation system carried by TSR.2 would provide all the navigation information required for Blue Water.

By the time this brochure appeared, the air-launched Blue Water and TSR.2 combination had undergone a number of changes since the 1960 proposal described previously. Firstly, and most strikingly, the means of carrying the missile had been changed from the semi-recessed carriage of a single round under the fuselage to twin-carriage at the inboard underwing store stations using specially designed pylons suited to the missile. Additional electronic equipment occupying approximately 2 cubic feet and weighing about 150lb would be positioned in the aft end of the weapons bay. The remainder of the weapons bay would be occupied by a non jettisonable fuel tank. An external ventral tank was also carried giving a total aircraft fuel capacity of 54,000lb. In order to achieve the maximum possible range, asymmetric carriage was advocated whereby only one Blue Water would be carried whilst the other missile was replaced by a drop tank.

Secondly, the original warhead was replaced by one increased to megaton size. For the purposes of this study a pessimistic value of warhead weight of 1,000lb was used and it was acknowledged that some structural strengthening and thermal insulation would be needed to meet the aircraft environment where the missile would be buffeted and subjected to kinetic heating by the airstream.

Thirdly, modifications to the guidance and fusing system were also needed, but none of these changes were of a fundamental nature.

The RAF's Valliants were assigned to SACEUR and were armed with US supplied weapons under Project E

Finally, the motor length had been increased by 4ft to increase the range.

Preliminary studies into what type of cooling system would be required to condition the missile guidance system, appeared to indicate that it would be best to use an evaporative total loss Freon 12 refrigeration system which would be built into the missile pylon and would use about half a litre of Freon 12.

It was proposed to release the missile in horizontal flight at 500ft or less and the tailcone fairing would now carry a number of decoys. If fired from an altitude of 200ft the stand-off range would be about 80nm without the aircraft being required to climb at the moment of launch. The accuracy of the system would give a CEP not in excess of 1nm at maximum range.

If greater ranges were required it was suggested that the missile motor could be lengthened without any radical new development problems to give a stand-off range of up to 150nm which would result in a slight increase in the overall range of the aircraft and missile combination.

When the Blue Water was launched at low altitude it was considered to have a high degree of inherent invulnerability for the following reasons:

a) It followed a high lateral acceleration trajectory throughout its flight as opposed to the zero lateral acceleration trajectory of a ballistic missile. It therefore presented a very difficult tracking problem to a defending radar and to any missile which might attempt to intercept it.
b) It had a high maximum speed along its trajectory and a wide variation of speed along its trajectory. Both of these characteristics significantly added to the difficulty which would be experienced in trying to track it.
c) It was intended to fly a trajectory whose maximum elevation was less than 60,000ft which would prove what is termed in the covering letter 'an embarrassing problem' to any defence employing nuclear warheads in their defensive missiles because they stood a good chance of being hoist with their own petard in trying to shoot the Blue Water down.
d) It had a small radar cross section
e) The shape of the trajectory was determined by the function programme loaded into the missile and not by Newton's Law of Gravity. The shape of the trajectory could thus be varied considerably from one missile to another making it impossible for a defensive system to be set up which was based on a significant knowledge of the missile's likely trajectory. Two missiles could be launched from the same aircraft simultaneously which followed widely varying trajectories to the same impact point.

Thus a defensive system which was set up against long-range ballistic missiles would be unlikely to be effective against Blue Water, thus imposing the necessity of some form of double missile defence upon the enemy.

It was suggested that this proposed combination of TSR.2 and Blue Water would represent a very effective strategic system which could be operational in the shortest possible time and at the minimum cost. This was because the maximum advantage would be taken of all the development work already done and paid for on the Blue Water project.

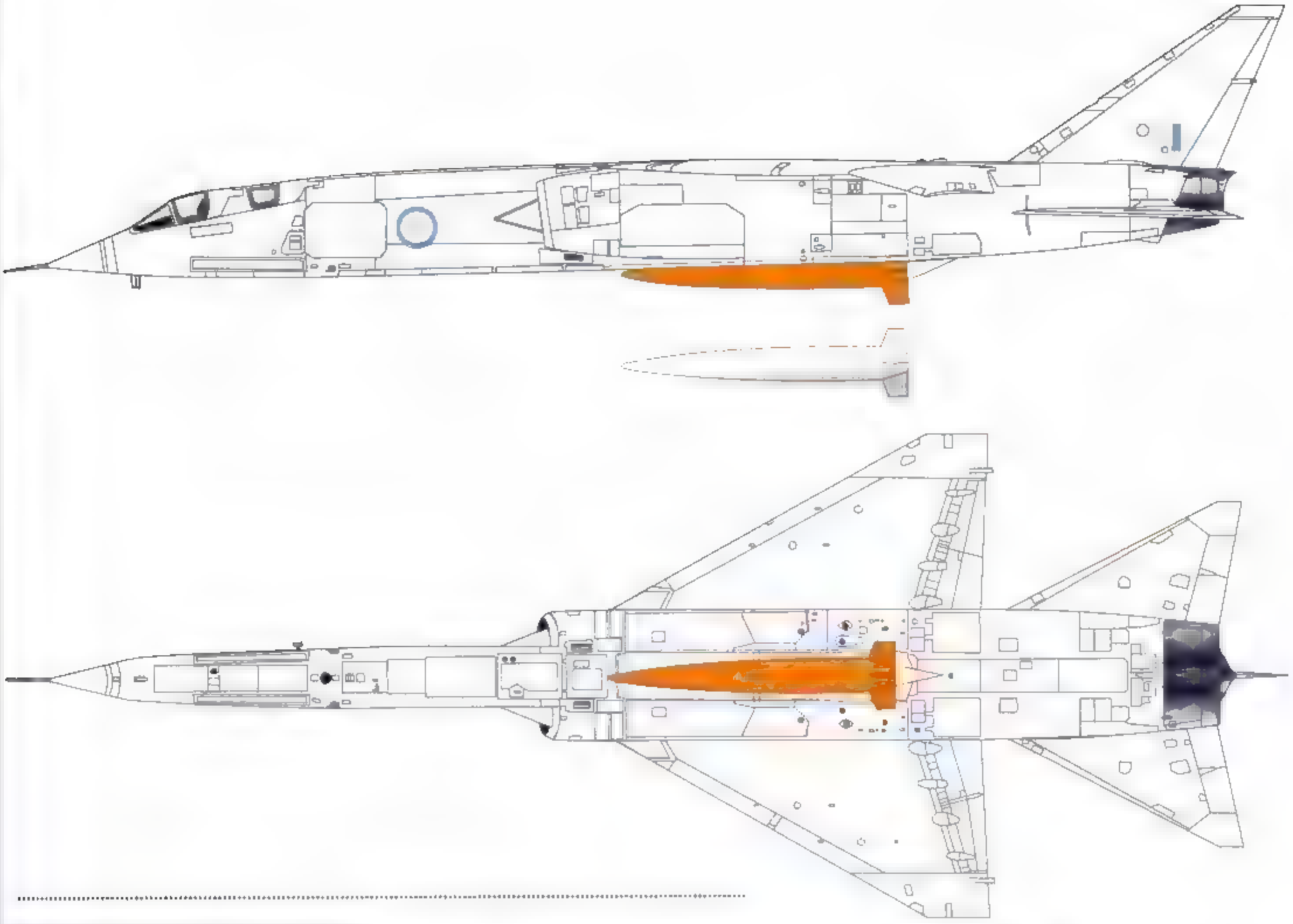
It was estimated that Blue Water could be developed for the airborne role in 3 to 3 and a half years with the system in operational service in 3 and a half to 4 years from the start of development. This short timescale was claimed to be possible as the majority of the missile design and development work had already been completed.

The total cost of the development of Blue Water for airborne use was now put at £33.9 million of which £16.6 million had already been spent on the missile, £12.3 million was earmarked for further missile development, £2 million for airframe development (thought to include V-Bombers and TSR.2) and £3 million for RAF evaluation trials.

A ballistic missile proposal

As effective as Blue Water was thought to be, the brochure stated that it did not represent the optimum weapon for TSR.2 in the strategic role. In order to achieve a maximum stand-off range and hence a maximum strike radius, a weapon of maximum range-to-weight ratio was required whilst to give the best accuracy from an inertial guidance system, a minimum flight time was required. To meet these considerations a pair of ballistic missiles would offer the best solution. At the same all-up weight of Blue Water of 6,600 lb. a ballistic missile would have a

The use of slipper tanks was very much the fashion in British aircraft design in the late 1950's and early 1960's. This photo shows to advantage the slipper tank designed for the Gnat. Similar tanks were designed for TSR.2 and would have been fitted in the Airborne Alert role



The Grand Slam Proposal of January 1963

As an alternative to Blue Water, BAC also proposed Project Grand Slam, 'System of Low Vulnerability for Tactical and Strategic Nuclear Strike from Aircraft'. This missile was to have been carried semi recessed into the weapons bay on the aircraft centreline. Powered by a solid fuel rocket motor, Grand Slam would have delivered the same type of nuclear warhead as was intended for use in Skybolt. This proposal was notable in that it carried a number of decoys which were intended to divert any attempt to destroy the warhead made by the defences. Grand Slam was 20 ft long, had a maximum diameter of 3 ft and a span across its fins of 6 ft.

stand-off range in excess of 300 nm. when launched from low level. These missiles would also carry decoys. As with the Blue Water proposal, one of the missiles could be replaced by an equivalent fuel tank if a maximum strike radius were required.

Grand Slam

As an alternative to the Blue Water, BAC also proposed Project Grand Slam, 'System of Low Vulnerability for Tactical and Strategic Nuclear Strike from Aircraft'. Not to be confused with the Second World War bomb of the same name, Grand Slam was a solid propellant rocket powered ballistic missile which was to be carried semi-recessed into the weapons bay of the TSR.2.

The missile was 20ft long with a maximum diameter of 3ft and a span across its fins of 6ft and was expected to have a range of 100nm. Grand Slam would be guided by the same inertial guidance system as Blue Water. The missile was to be launched from low level by an aircraft computer induced toss bombing manoeuvre with the missile being released by the computer at exactly the right moment with the aircraft aligned at the target whilst in a 45 degree climb.

Grand Slam did not require any means of thrust termination or reversal or even altitude stabilisation after motor burnout. The velocity for range was to be managed by means of impulse rockets.

The missile would climb to an altitude of approximately 67,000ft where the warhead stage would separate along with 40 decoys which had been developed previously for the now abandoned Blue Streak, each of which had the same radar cross section and mass-drag ratio as the real warhead which was the same type of warhead intended for use in Skybolt.

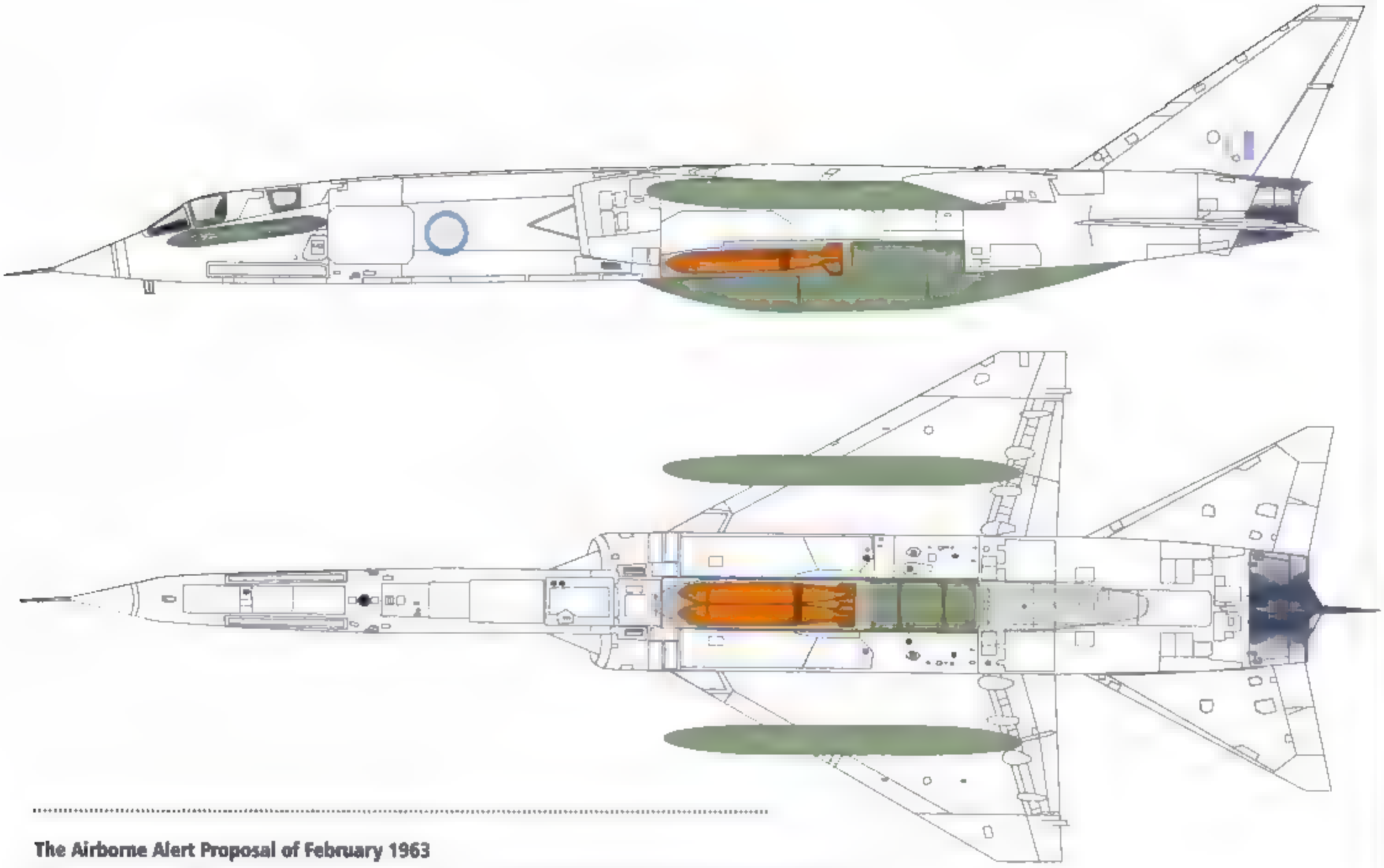
Using standard fuel, a 250 gallon weapons bay tank and the two 450 gallon wing tanks, the TSR.2/Grand Slam combination was expected to have a strike radius of somewhere in the region of 1,500nm.

It was estimated that the Grand Slam would take 3 to 5 years to develop at a cost of more than £20 Million.

After due consideration it was believed that the timescale for this project had been underestimated and a more realistic estimate would be between four and six years. This implied that the system could not be deployed operationally until 1968-69 and would therefore be too late as a stop-gap. It was also considered that pulse Doppler AI equipped fighters and improved air-to-air weapons having a low-level capability would eventually lead to significantly increased losses. Furthermore, it was noted that the toss launch technique would lead to an increase in vulnerability because the height gained during the manoeuvre would expose the aircraft to enemy defences.

Airborne Alert

By February 1963, BAC had made a third proposal in a brochure which described how TSR.2 might be employed in the continuous Airborne Alert role similar to that employed by USAF Strategic Air Command, which was being considered by RAF Bomber Command at about this time. This brochure described a possible Airborne Alert System facilitated by flight refuelling with Victor tankers.



The Airborne Alert Proposal of February 1963

During February 1963, BAC submitted a brochure which described how TSR.2 might be utilised in a continuos Airborne Alert role. In this role TSR.2 would carry its weapons internally allowing both a big ventral fuel tank and underwing drop tanks to be carried externally which could be refuelled in flight via the detachable Flight Refuelling Probe. Thus configured, TSR.2 would be capable of patrolling over the North Sea for nearly two and a half hours before needing to be refuelled in flight.

The 1959 Specification for OR 343 which became TSR.2 stated that provision was to be made for strongpoints and ducting in the wing to permit the carriage and safe jettisoning of 450 gallon drop tanks, for the carriage of a 570 gallon fuel tank in the weapons bay and a flight refuelling hose which would allow TSR.2 to be used as a 'buddy tanker'. All the TSR.2's fuel tanks were to be capable of being refuelled in flight from a V-Bomber tanker using the probe and drogue method. By the time the Airborne Alert proposal was made in early 1963 it was proposed that this fuel system be augmented by the addition of a 1,000 gallon ventral drop tank carried on the outside of the weapons bay.

In the Airborne Alert scenario the TSR.2 would carry its freefall or laydown weapons internally along with the weapons bay fuel tank. Externally, the TSR.2 would also carry the big ventral drop tank and a pair of overload slipper tanks on the inboard wing stores stations. TSR.2s assigned to airborne alert duties would need a strengthened undercarriage and modified brakes in order to take-off and possibly land overweight because of all the extra fuel it would be expected to carry and would be forced to operate from a Class 1 airfield.

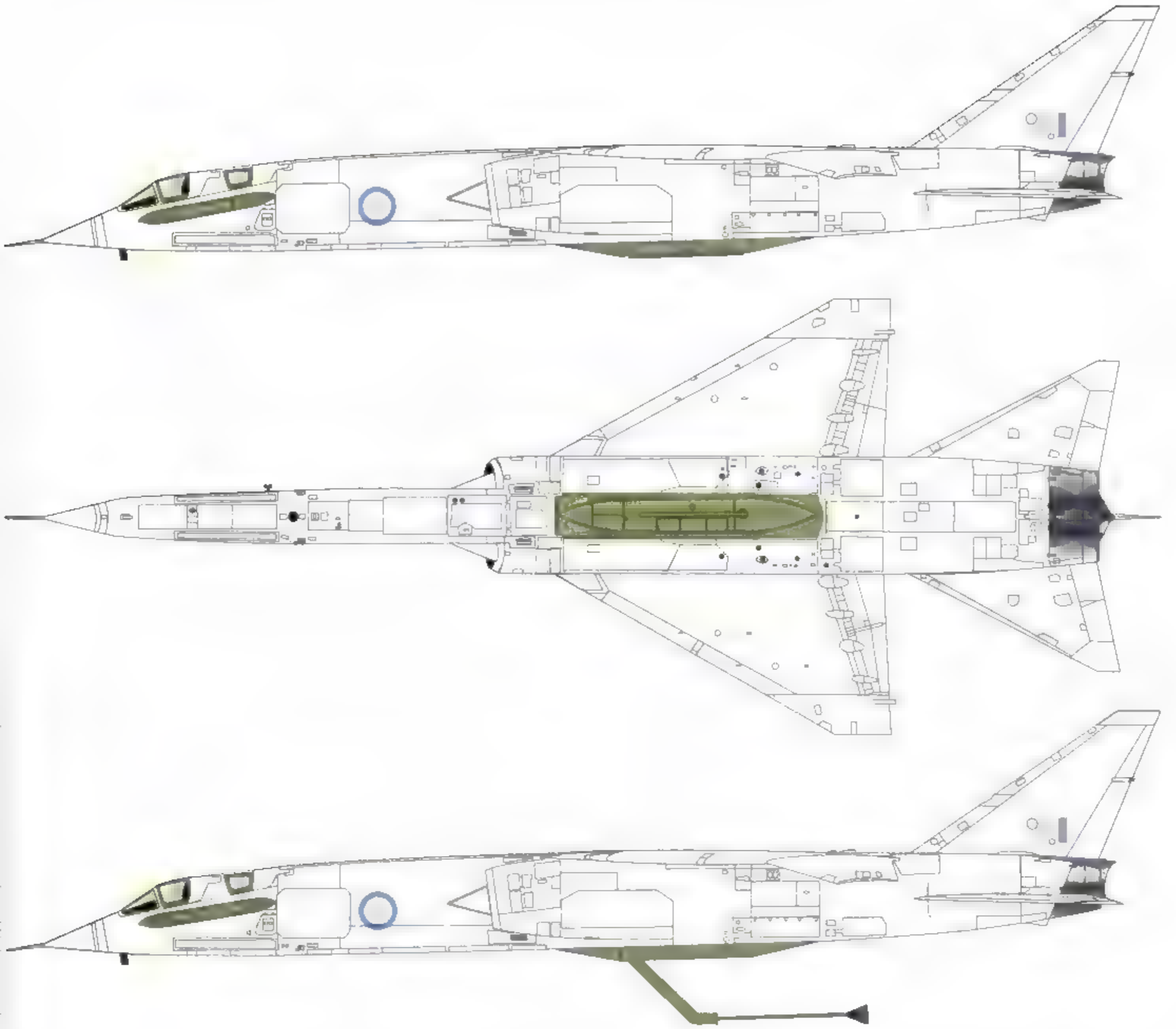
Thus equipped, the TSR.2 was expected to be able to fly a patrol over the North Sea for nearly two and a half hours before being refuelled in flight. At the end of this period the TSR.2 would only be capable of penetrating the periphery of the Soviet Union perhaps as far as Leningrad but after each refuelling, the TSR.2 would be capable of a much deeper penetration. The basic patrol was expected to last some seven and a half hours with two refuellings.

The defined minimum-range sortie would begin from the point where the fuel load carried on board TSR.2 had been reduced to the point where refuelling was needed. All the drop tanks would be jettisoned and TSR.2 would begin its transit at high altitude for a distance of up to 600nm. It would then descend to low level for a penetration of up to 440nm before striking the target and returning to high level for 590nm to recover to a NATO country.

A typical maximum range sortie would begin immediately after an in-flight refuelling with a 600nm transit at high altitude during which time the fuel from the overload tanks would be used. These would be dropped as they emptied, with the wing tanks being discarded first, followed by the ventral tank which would be dropped as TSR.2 descended to low level. The penetration flight of 1,070nm would therefore be carried out on internal fuel at low level. After striking the target, TSR.2 would return to high altitude for 1,220nm to recover to a NATO country.

It was pointed out that a standard TSR.2 could carry out a somewhat shorter Airborne Alert, being refuelled after one and a

The Victor K.1 tanker seen here without its FRL Mk. 20 wing pods was the mainstay of the RAF's tanker fleet in the late 1960s and early 1970s



The Buddy Tanker Proposal of 1963

To meet the 'Buddy Tanker' requirement which was written into the original OR 343 specification, Flight Refuelling Ltd designed the Mk. 26 flight refuelling pack to fit inside TSR.2s weapons bay. In order to ensure sufficient vertical separation between the Buddy tanker and receiver, the refuelling pack incorporated a retractable boom approximately 9 ft long which swung down below the pack during the refuelling manoeuvre. Horizontal separation was to be maintained in the usual way by trailing the basket behind the buddy tanker.

half hours. It was claimed that one Victor Mk 1 tanker could refuel two TSR.2s at a position 50nm off the UK per sortie. It was also claimed that a force of 60 strengthened TSR.2s and 14 Victor Tankers could maintain 10 TSR.2s continuously airborne during a period of tension.

As an alternative, BAC suggested that the range of the TSR.2s could be extended by flight refuelling en route to the target. It is not clear whether this refuelling was to be done by Victor Tankers or by other TSR.2s acting as 'Buddy Tankers'.

To meet the 'Buddy Tanker' requirement which had been written into the original specification, Flight Refuelling Limited designed the Mk 26 flight refuelling pack to fit into the TSR.2 weapons bay. The Mk 26 was to have an integral fuel tank with a capacity of 450 imperial gallons (2,025 litres) of disposable fuel which it was capable of passing to a receiving aircraft at M 9.0 at 33,000ft at a rate of 300 imperial gallons (1,350 litres) per minute.

In order to ensure sufficient vertical separation between the buddy tanker and receiver within the refuelling envelope, it would be necessary for the aircraft to adopt a high angle of attack. In order to reduce this angle whilst maintaining a prudent vertical separation, the Mk 26 refuelling pack incorporated a retractable boom approximately 9ft long which swung down below the pack during the refuelling manoeuvre ensuring a vertical separation between the two aircraft of approximately 12ft. Horizontal separation was maintained in the usual way by trailing the basket some distance behind the Buddy Tanker in the usual way by reeling out the hose which was contained in a Hose Drum Unit in the front of the buddy pack.

A mockup of the Mk 26 buddy pack was completed and installed in the mockup of the TSR.2 in order to ensure that all the necessary electrical, hydraulic and fuel systems were compatible with those of the aircraft, and to ensure that ground handling would be a practical proposition. It was intended that the Hose

Drum Unit and the boom would be installed in Canberra WH374 for the initial flight development trials but before this could come to pass, the requirement for buddy refuelling for TSR.2 was dropped from the specification in Amendment List No. 4 in April 1963.

Hatchet

The Hawker Siddeley group tendered a de Havilland proposal for a ballistic missile called Hatchet. Hatchet was a short-range low-altitude ballistic weapon which took the form of an unguided rocket consisting of a warhead and a solid rocket motor within a suitable aerodynamic structure. It was suggested that this weapon could be carried both by V-Bombers and TSR.2 . The missile weighed 3,050lb was 18 inches in diameter and was 24 and a half feet long. It was proposed that the power plant would be a Rook solid fuel rocket motor which was already in production and that as it lacked any form of guidance, it should spin in flight for stability and to offset any misalignment of the thrust, this being facilitated by offset fins.

The unguided missile would be fired from 1,500ft at the target on an accurate heading so that the subsequent missile track would be over the target whilst the aircraft broke away. An accuracy of 1.5nm CEP was claimed with a range of between 25 and 65nm.

It was estimated that this system would take 2 years to develop at a cost of £0.865 million plus the additional costs which would be incurred in mating the missile to the V-Bombers and TSR.2.

Consideration of this proposal suggested that if it was thought feasible that ■ V-Bomber could get to within 25 miles of the target without prohibitive losses, then Hatchet did appear to be viable as ■ 'stop-gap' weapon on the grounds of timescale, cost and aircraft utilisation as it could be carried by TSR.2 as well. There were however doubts about claimed degree of accuracy.

This was one of the less well documented proposals and it has proved impossible to locate a general arrangement drawing to illustrate it.

AST 1168

De Havilland Ltd, Bristol Aircraft Ltd and the RAE all put forward a suggestion for a weapon based upon the tactical Air-to-Surface Missile which was being developed to Air Staff Target 1168 which ultimately became Martel.

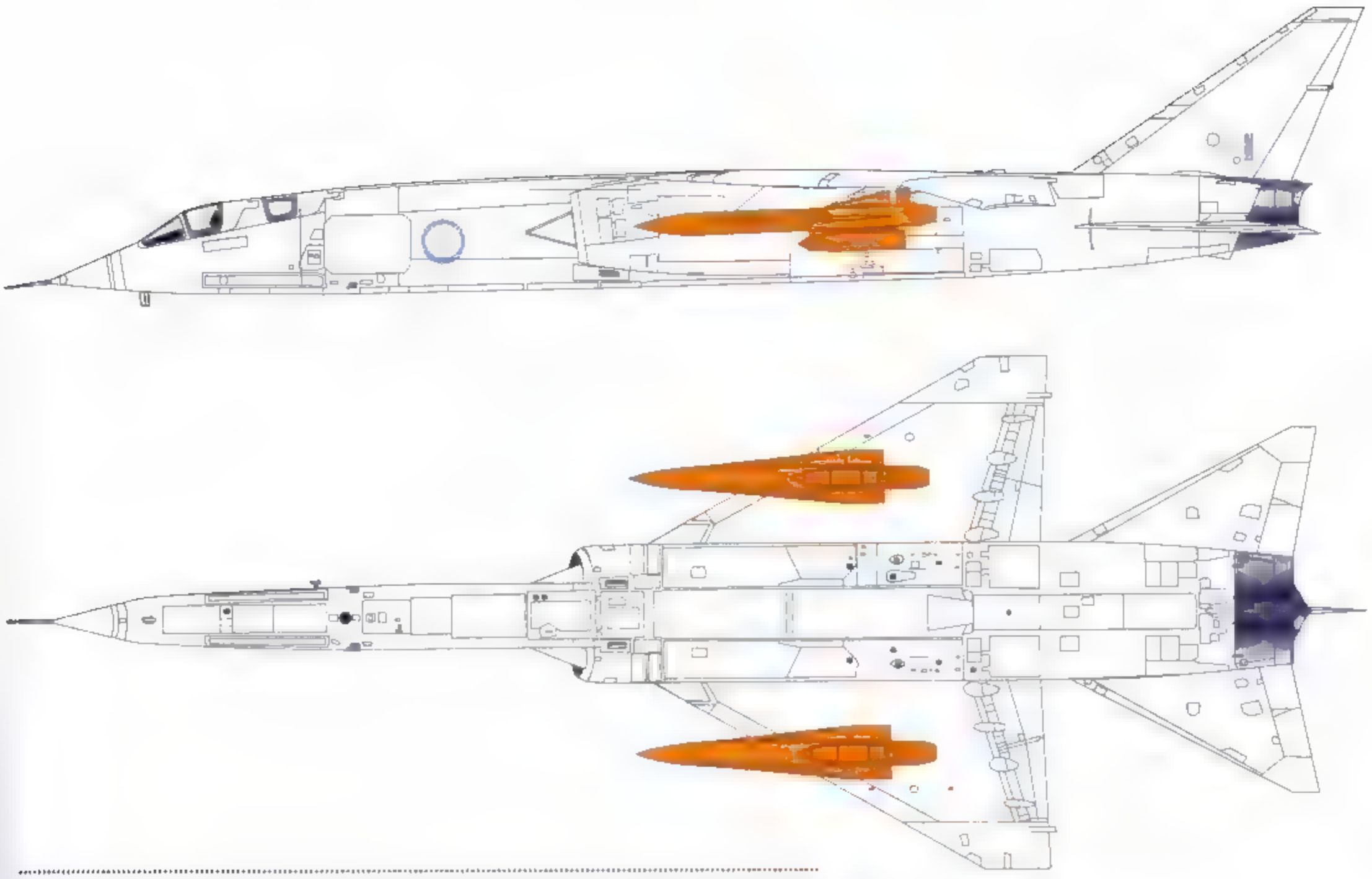
The de Havilland weapon was scaled linearly by 13 percent to accommodate the required warhead in a body diameter of 15

A mock up of the FRL Mk. 26 flight refuelling pack designed for TSR.2 on its ground handling trolley

The pack was fitted to a mock up of TSR.2 ■ ensure that all the fuel line and electrical connections were compatible. ■ is seen here in the closed cruising position

Starboard side view showing the various access panels in the open position

Post side rear view showing the boom partly deployed. The drogue basket is clearly visible in its fully retracted position



RAE Technical Memorandum WE.1509 Small Ramjet Powered Cruise Missile proposal of March 1963

Following the submission of the various Stop-gap Deterrent proposals during the first three months of 1963, the RAE prepared a report to assess the merits of each of the proposals. At the same time, the RAE also offered a number of proposals of its own within each class. In the cruise missile category, as the RAE considered enlarging the AST 1168 Martel impractical, it offered a cruise missile of its own design.

The proposed weapon was a ramjet powered missile of about 2,500lb weight which might be powered by a slightly modified version of the ramjets which powered a Bloodhound missile. The RAE proposal was to have a range of 50 miles, a length of 245 in, body diameter of 18 in and a span of 45 in and would thus be capable of being carried by the V-Bombers and Buccaneer as well as TSR.2. It was not proceeded with despite being considered the most technically attractive solution to the problem of equipping an aircraft with a stand-off capability but may have been the basis for a cruise missile for TSR2 in the 1970s

inches and the length became 14ft 6 inches. If the TV equipment was removed and replaced by an inertial guidance system there remained sufficient room for about 600lb of rocket propellant which gave a range of between 22 and 26nm at a maximum speed of M=1.4. One such weapon could be accommodated within the weapons bay of TSR.2 if the wings were slightly redesigned.

The Bristol Aircraft Ltd proposal simply replaced the high explosive warhead with a nuclear warhead whilst retaining the control system from the original AST 1168 proposal. Terminal guidance was no longer needed and the expected CEP was somewhere in the region of 1.5nm. The range of the missile was extended from 12nm to 25nm by the addition of a boost sustainer unit to the rear of the basic AST 1168 missile thus increasing its length to 15.83ft. The research and development effort was estimated at £20 million over four to five years and this proposal received short shift, being dismissed as a stop-gap on the grounds of cost alone.

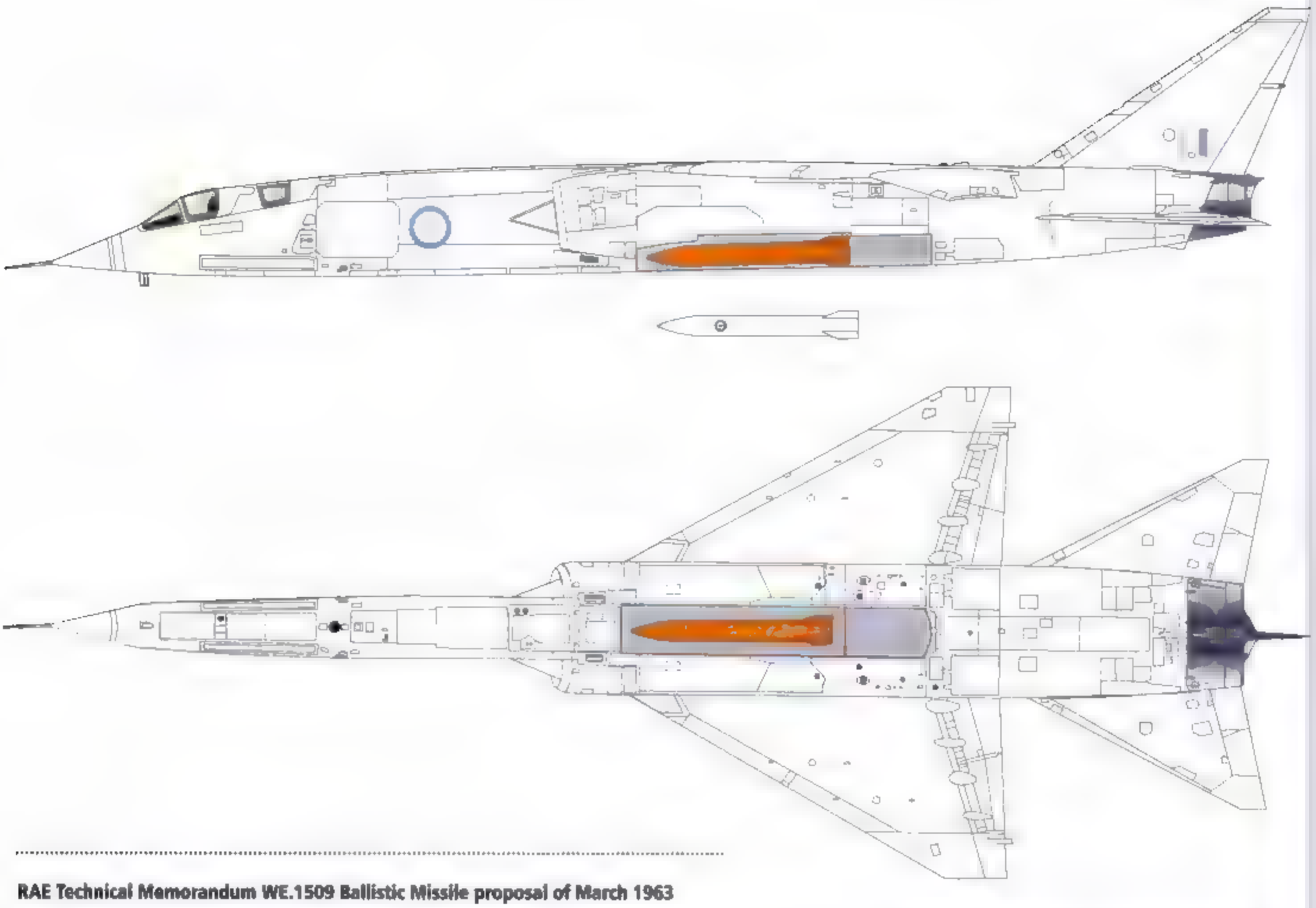
The RAE proposal was quite similar to Bristol's. Weighing 1,500lb when launched from TSR.2 in straight and level flight at 0.9M the missile would have a range of 30nm travelling at M=2 which could be extended up to 50nm if a toss launch manoeuvre were employed. It would be guided by a cheap, simple inertial navigation system, expected to give an accuracy of 2nm. CEP. It was noted that greater range and faster speeds would be obtainable at modest increases in weight and more than one weapon could be carried on V-Bombers, Buccaneer and TSR.2. If used with the Buccaneer, the weapon could be based on an aircraft carrier which would give it increased mobility. Development cost was put at £15-20 million with a cost of about £30K for each missile. A development timescale of 4 years was considered feasible and a production time would likely be two years for 100 missiles. The RAE proposal was considered to be a viable stop-gap weapon and was to be the subject of a further study.

Stop-gap review

Following the submission of these stop-gap proposals, the RAE was invited to prepare a report assessing their suitability. In March 1963 the results of this assessment were published as RAE Technical Memorandum WE.1059 entitled 'Stop-Gap' Deterrent Weapons'. This defined a Stop-Gap Deterrent Weapon as one which would fill in the gap between the time when V-Bombers armed with Yellow Sun or Blue Steel became unacceptably vulnerable in 1963/66 and the time at which Polaris firing submarines became available which was assumed to be 1968/69. After examining the likely Soviet defences which would have to be penetrated, the memorandum then went on to assess the various suggested stop-gap systems. After discussing those which only applied to the V-Bombers, the Yellow Sun freefall bomb delivered after a low-level cruise and Blue Steel, the Memorandum then moved on to discuss those which might be delivered by TSR.2.

The megaton laydown bomb to OR 1177

When compared with Yellow Sun, the weapon to OR 1177 (WE 177B) had the advantage that it could be carried on the high-speed carriers such as TSR.2 and thus had a high chance of being carried to the city perimeter defences. Moreover, since it was



RAE Technical Memorandum WE.1509 Ballistic Missile proposal of March 1963

Having considered the Blue Water, Grand Slam and Hatchet proposals, the RAE suggested that it might be preferable to develop a simple unguided ballistic missile which would consist of the nose portion of the OR 1177 Laydown bomb whose tail would be replaced by a finned rocket motor.

This proposal was considered to be suitable for carriage by TSR2, the V-Bombers and the Buccaneer. It was to have a range of between 60 and 85 miles, being sufficiently well armoured to be all but immune to interception by SAMs fitted with conventional explosive warheads. It was to have weighed 2,500lb, been 210 in long with a diameter of 18 in and a span of 35 in.

not necessary to climb over the defences to deliver the weapon, credible numbers of aircraft should be able to penetrate these defences. This weapon was already under development and was expected to be deployed within three years at a cost of £1-2 million over and above the cost incurred in developing the initial kiloton yield tactical weapon.

Cruise missiles

By this time it had become clear following further detailed investigation that there was no prospect of converting the AST 1168 missile into a stop-gap as it would not actually attain the required performance. At a weight of 1,000lb the missile would only have a range of about 15nm which was considered to be totally inadequate for a stand-off strategic missile, and the visual guidance called for a low speed missile which made it vulnerable to static strategic defences. Therefore, to meet a stand-off range requirement of 25-60nm and a dash speed of about M=2 a very much scaled-up AST 1168 would be needed.

For the purposes of the RAE investigation it was assumed that the speed of M=2 was only needed during the crossing of the defences and that as the centre of the target was approached the missile range could be extended by gliding down to about 0.9M or a little lower. It was assumed that it would also be possible to control the flying height of the missile, perhaps down to as low as 200ft, by use of a radio altimeter.

A large number of proposals along these lines were examined and it appeared that a solid rocket of about 2,000lb in weight, approximately 19ft long with a wingspan of 45 inches could be developed to fit the Buccaneer, TSR.2 and V-Bombers but the maximum range of such a weapon would only be about 25 nm. which was insufficient.

A solid rocket of about 5,000lb with a length of approximately 26ft and a diameter of 2ft would give a range of about 55nm but whilst this would go on the TSR.2 and V-Bombers, it might be difficult for the Buccaneer to carry. This proposal could be developed in about 4 years at a cost of between £20-25 million.

Blue Water could be adapted to cruise at low level but would need its motor to be further developed as in a low-level cruise, the existing motor could not achieve the desired range. Therefore, whilst Blue Water parts might be used in it, the 5,000lb rocket mentioned above would be a better and cheaper proposition than a modified Blue Water.

A ramjet missile of about 2,500lb using one of the ramjets very slightly modified from the Bloodhound missile might be developed to give about 50/55nm range. This missile could fit in all the aircraft considered, including TSR.2. The missile would use an existing motor as a boost and this might sensibly be retained in the missile after use, for simplicity. The speed of the missile could be maintained at M=2 for the whole of the flight and might present greater potential for stretch as the fuel consumption was much lower than in a rocket motor. This proposal could be developed for between £15–20 million in about 4 years.

It therefore appeared that assuming that the carrier aircraft could penetrate the perimeter defences, a very low-level cruise missile could be developed in an acceptable timescale which would be sufficiently invulnerable to city defences by virtue of its speed and height. The most attractive choice in this class appeared to be the ramjet which would enable the parent aircraft

to avoid the city defences and which was small enough to go on all the aircraft considered

Ballistic missiles launched from aircraft

A number of proposals made for short-range ballistic missiles had been studied which included Grand Slam, Blue Water and Hatchet.

All these proposals were for weapons with a range of between 100 and 200nm which was thought to be rather more than was necessary to avoid city perimeter defences but was insufficient to avoid the carrier aircraft having to penetrate Soviet territory. All were heavy missiles which only the V-Bombers or TSR.2 could carry and would be expensive to develop. Grand Slam and the Hawker Siddeley proposal were thought to be likely to take 5 or 6 years and cost between £50 and 60 million. The air-launch Blue Water would be cheaper but was considered unlikely to be more than £20 million cheaper and a year earlier in development.

The RAE considered it possible that as all these missiles had a comparatively low velocity for a ballistic missile at between M=2 and M=4, it might be possible for them to be intercepted by the Soviet SA2 Anti Ballistic Missile System, and furthermore, as launching them in the first place necessitated the carrier aircraft having to execute a rapid pull-up from low level, the SA3 SAM system would have a good probability of achieving a kill after weapon release.

In the light of this, the RAE thought that it might be preferable to develop a simple unguided ballistic missile which would be cheaper to develop at £15–20 million within a 3–4 year timescale with most of the design effort being concentrated on making the missile simpler and harder to destroy.

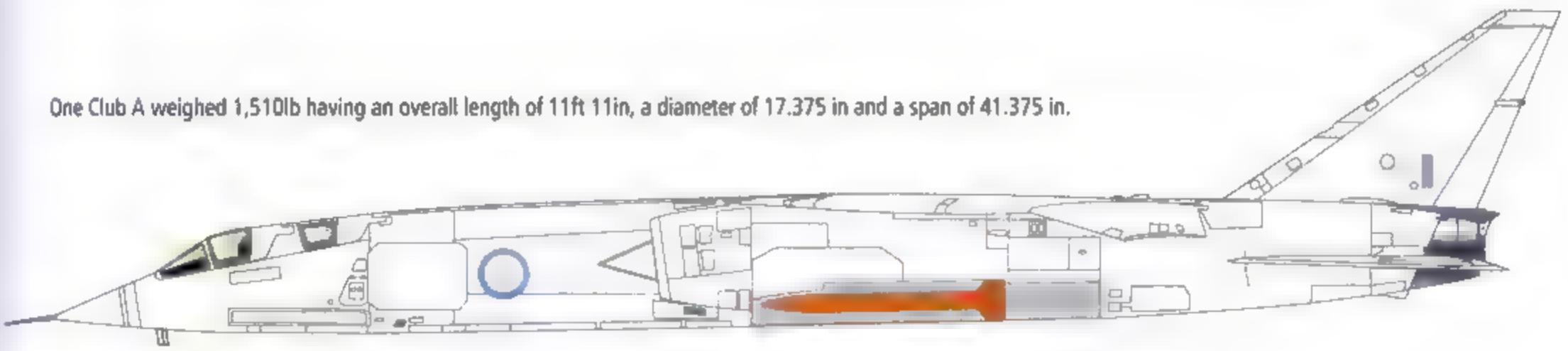
It was proposed that this could be accomplished by a 2,500lb missile which would be essentially composed of the nose portion of the OR 1177 laydown bomb (i.e. the WE 177B) with the bomb tail replaced by a finned rocket motor. This would be capable of being carried on all the considered aircraft including TSR.2. It should be simple to provide cheap decoys for such a system by providing duplicate missiles with concrete heads, but these could not be deployed in sufficient numbers to saturate the defences. The major objection to this type of missile was thought to be its lack of accuracy which was expected to be of the order of 2.5–3nm CEP.

Following the publication of this Memorandum, BAC submitted two designs for ballistic missiles along the lines suggested by the RAE.

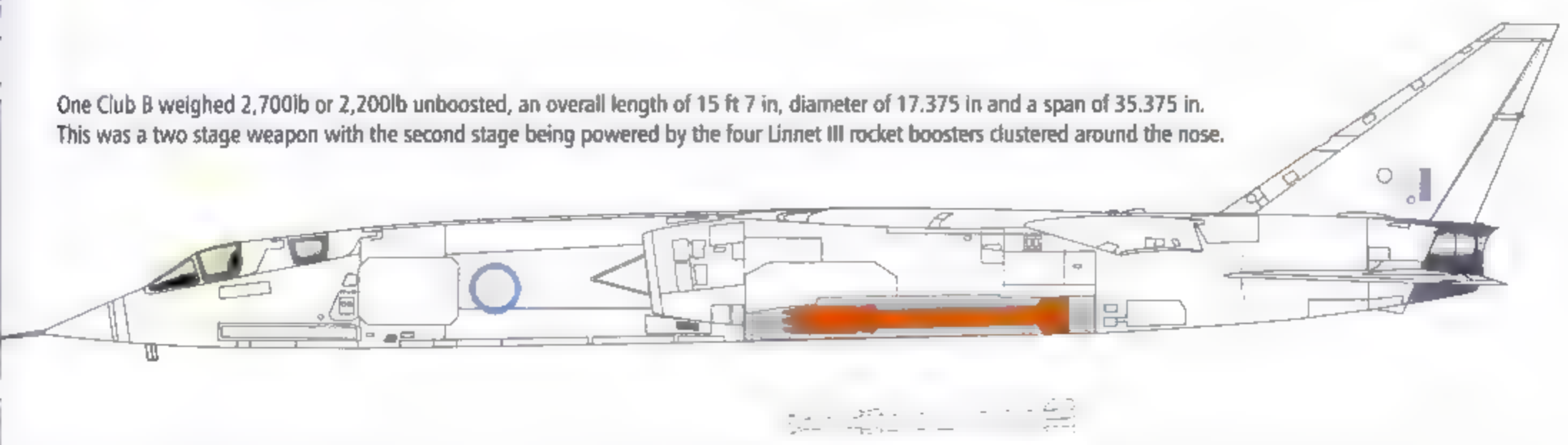
The first design was called One Club A which had an all-up weight of 1,510lb, overall length of 11ft 11 inches and a diameter of 17.375 inches. Powered by a Raven rocket motor this was an unguided weapon intended for internal carriage on TSR.2 and the Buccaneer.

The second design was called One Club B which was somewhat bigger with an all-up weight of 2,700lb It was longer at 15ft 7 inches but had the same diameter as One Club A. The major difference between the two was that One Club B appears to have been a two-stage weapon to give a greater range. The

One Club A weighed 1,510lb having an overall length of 11ft 11in, a diameter of 17.375 in and a span of 41.375 in.

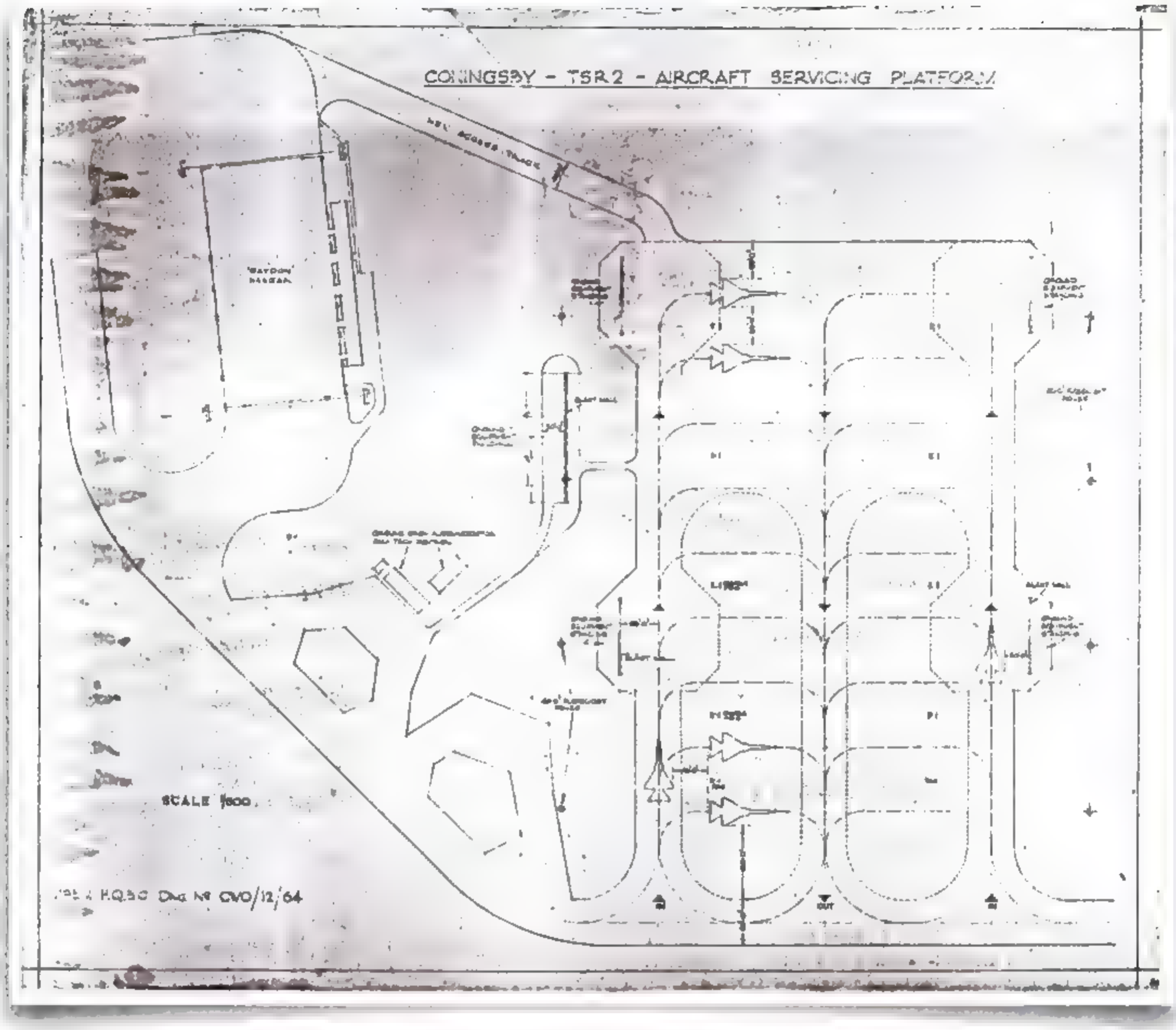


One Club B weighed 2,700lb or 2,200lb unboosted, an overall length of 15 ft 7 in, diameter of 17.375 in and a span of 35.375 in. This was a two stage weapon with the second stage being powered by the four Linnet III rocket boosters clustered around the nose.



BAC One Club A and One Club B proposals circa 1963

Following the publication of RAE Technical Memorandum WE.1509 BAC submitted two designs for ballistic missiles along the lines suggested by the RAE. These were known as One Club A and One Club B. Powered by a Raven rocket motor, these unguided weapons would have also been suitable for carriage by the Buccaneer.



The proposed layout of the TSR.2 Aircraft Servicing Platform at RAF Coningsby, circa 1964 © Crown Copyright

Coningsby TSR.2 Aircraft Servicing Platform

In December 1963, an Aircraft Servicing Platform (ASP) was considered to be essential for the efficient operation of TSR.2 aircraft at Coningsby. It was intended that the ASP would provide for concentration of effort and the best utilisation of manpower, critical ground equipment and other resources. A Working Party was set up to study and make recommendations for an ASP suited to the proposed TSR.2 OCU at Coningsby with regard to the facilities required, its design characteristics and site. In February 1964, their preliminary study showed that the requirements and purpose of the ASP would govern its size, which in turn would govern its siting. These factors were therefore considered before the facilities.

Nuclear Safety Distances

It was decided that as the primary role of Coningsby was to be training and development flying and that as operational aircraft could operate from the existing Operational Readiness Platforms or dispersals, no consideration need be given to the inclusion of nuclear armed aircraft on the ASP.

Hunters

At this time, there was no firm requirement to operate Hunters from Coningsby. It was considered however, that if such a requirement was to arise that their flying and servicing pattern would be entirely different from that of the TSR.2. It was therefore decided that the Hunters would operate from a different area, No. 5 or 6 Dispersal was considered to be entirely suitable and that the ASP would therefore be used by TSR.2 only.

Number of TSR.2s required

The total number of TSR.2s based at Coningsby was considered to be unlikely to be greater than 23 aircraft. It was thought that there should be sufficient hangar accommodation for all of these and it was agreed that only turnaround servicing and minor and quick rectifications should be undertaken on the ASP. On this basis it was decided that 17 TSR.2s would be the maximum number of aircraft which would need to be accommodated.

Engine Running and Taxying

Though there was at this time no information available on the amount of noise, heat and blast effects likely to be experienced on the ASP from TSR.2s at taxying engine power, it was noted that the V-Bombers and Lightnings seemed to cope without endangering neighbouring aircraft. It was therefore decided that the ASP should be designed as a full operating platform.

Size and Shape of the ASP

It was decided that the most compact shape with the minimum number of blast hazards would be a rectangle containing two rows of aircraft facing inwards and using a common exit track. Two access tracks would be provided at the rear of each line of aircraft which would permit one way traffic on the ASP itself and on the main taxyway. It was agreed that a minimum distance of 50 ft should be allowed between wing tips should be allowed to give manoeuvring space for the aircraft taxying in and out since the TSR.2 was quite long in relation to its span and sufficient space would thus be allowed for ground equipment to be used, for the Power Distribution Cubicles and for vehicular access without blocking said access. The size and shape of the ASP was shown in diagrammatic form

second stage was powered by four Linnet III rocket boosters arranged around the outside of the lifting body warhead which after separation acted as a glide bomb.

The details of the One Club designs are somewhat sketchy with no performance details currently available, but it can probably be assumed that the One Club B design would have the longest range by virtue of its bigger size which would allow more propellant to be carried by the first stage, and possibly a greater velocity during the terminal stage of the flight by virtue of the warhead having four boosters which might also have added to the weapon's range.

Decision

As far as the DOR at the Air Ministry was concerned, it was quite clear that the adoption of the WE 177B for TSR.2 would be the quickest, most simple and cheapest means of giving TSR.2 a stop-gap deterrent capability. In a summary of the prevailing situation in February 1963, a loose memo stated that the case for TSR.2 with two laydown weapons seemed to be a convincing one. When the dispersal capability was taken into account it appeared that TSR.2 thus armed would seem to have a very good chance of giving the UK a sufficiently high deterrent capability for its needs and offered the opinion that it was perhaps a pity that by this time the UK had committed itself to purchasing the Polaris system.

Thus had TSR.2 actually entered service it would have been armed with two free-falling WE 177A or WE 177B weapons which could have been used in either the tactical or strategic nuclear strike roles.

Once the decision to equip TSR.2 with the WE 177B had been taken, all the proposals for strategic stand-off weapons were consigned to the archives. During 1964, what was by this time the Air Force Department of the Ministry of Defence was approached by the Ministry of Aviation about a proposal by Short/Elliot/Rolls Royce that these firms should unite to produce a feasibility study at their own expense for a strategic long-range low-level air-to-surface missile for the TSR.2.

The Air Force Department replied on 9 June 1964 by stating that whilst they might at some time wish to put up a requirement for this kind of device to prolong the life of the TSR.2, they had no such requirement then and if such a proposal were to be paraded at this stage it would certainly find no support in the Central Ministry of Defence. Furthermore, it was far from clear whether such a requirement, were it to emerge, would be anything like the system which had been outlined. It was considered therefore that it would be quite wrong for the Ministry of Aviation to encourage in any way any of the firms in this enterprise. If on the other hand in spite of the lack of encouragement they decided to go ahead, then the Air Force Department would of course be interested to see the results.

It would appear that this was the end of the matter as the TSR.2 weapon system developed from this point focused on the free-falling WE 177A and laydown WE 177B. These systems will be described in a later chapter.

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as reproduced here. The overall size of the concrete measured about 800 ft long by 500 ft wide.

Power Supplies
Suitable power supplies would be provided by Power Distribution Cubicles (PDCs) with sufficient outlets to satisfy the servicing needs of two aircraft were to be sited between each pair of aircraft. These were to provide single and three phase mains supply and would be used for electrically driven ground power units and standard electrical ground equipment.

Lighting
It was agreed that a concentrated aircraft park of this nature should be floodlit for safety as well as for working convenience. The exact type of this lighting could be left to lighting experts to decide upon at a later date but it was suggested that this should take the form of lights mounted upon poles some 40 ft high which were situated outside the ASP area.

Ground equipment areas
The hardstanding in front of the existing garages was considered to be suitable as a ground equipment hardstanding. Whilst there was considered to be sufficient space for in use items of ground equipment between aircraft, it was acknowledged that certain items of equipment might need to be moved in an adjacent aircraft was taxying and that the outer flanges of pans 1, 2, 3 and 4 were outside the proposed ASP and these areas which were some 150 ft long by 30 ft wide would be readily available providing that they were protected by blast walls.

Blast Walls
Although taxying power would be needed on the ASP, higher power would be necessary to overcome the aircraft's inertia for the aircraft to begin to move from rest. Protection of exposed areas such as the dispersal offices and ground equipment hardstandings would be necessary

Completion date was ideally considered to be July 1966 which would have allowed the first TSR.2s ■ Coningsby to operate in fair conditions. If this date proved to be impossible then the latest acceptable date would be April 1967.

By July 1964 it was considered necessary to complete the detailed design of the ASP and the Air Force Department at the MoD wrote to HQ Bomber Command on 2 July to address a number of points which had emerged from the Working Party's interim report. Three points covered in this letter are of interest. Firstly the MoD was of the opinion that 18 TSR.2s needed to be accommodated on the ASP. Secondly, the MoD was of the opinion that co-location of both TSR.2s and Hunter T.12s on the ASP to further the principle of centralised control of servicing and to improve utilisation of common critical resources should be reconsidered and finally, that the access track which was shown on the plan as being 40 ft wide should be a minimum of 50 ft to allow taxying.

This design of ASP was apparently intended to be unique to Coningsby due to its training role with there apparently being no suggestion that the design be replicated on operational stations which would presumably have seen the TSR.2s dispersed around the airfield in the usual manner. What eventually happened to this proposed ASP design is not known.

Chapter 4

Proposed Initial Deployment

THE SUGGESTION THAT TSR.2 BE USED AS PART OF THE STRATEGIC nuclear deterrent using stand-off weapons did, for a time, raise the spectre that additional TSR.2s would need to be ordered over and above those required for use in the tactical role. This was because it seemed likely that TSR.2s used as a deterrent might need special modifications for this role. If this was so, then there might not be enough TSR.2s left after the necessary number were modified for the Strategic Strike role to meet the RAF's commitments in the original Tactical Strike and Reconnaissance roles. Additionally, even if this was not the case, it would not be possible for the same aircraft to be in two places at once fulfilling a different role in each.

The decision to procure the megaton laydown WE 177B for TSR.2 laid these concerns to rest and the production programme was allowed to continue without modification. Initially, twenty pre-production aircraft were ordered. The first nine aircraft XR219-XR227 ordered to contract No. KD/2L/02/CB42(a) which have already been mentioned, were intended to be retained by the manufacturers for various trials and further development work. These were to be followed by eleven aircraft, serials XS660-XS670 ordered to contract No. KD/2L/13/CB42(a) dated 28 June 1963. The first five of the eleven, XS660-XS664, would be allocated to A&AEE Boscombe Down, whilst the remainder, XS665-XS670, were intended for issue to an RAF squadron.

March 1964 also saw serial numbers allocated to two further production batches of TSR.2s. These were XS944-XS954 (11 aircraft) and XS977-XS995 (19 aircraft contract KD/2L/16/CB42(a) dated 20 March 1964) which made up the first 30 full production aircraft which were intended for the RAF. These serial numbers are the only ones known to have been allocated to TSR.2s by the time of its cancellation.

There is very little evidence to suggest which serial numbers might have been allocated to TSR.2s after XS995. Perhaps the numbers most likely to have been allocated are those which were allocated to the F-111s ordered in TSR.2's place. These were XV884 – XV887 (4 TF-111K aircraft) and XV902 – XV947 (46 F-111K aircraft) which gives a total of 50. If this serial run had been unbroken then the total number rises to 63 aircraft which when taken with the 30 known production serials and the 6 pre-production aircraft which were to be brought up to full production standard brings the total up to 99 of the 110 aircraft of the March 1965 requirement.

If a follow-on order had been placed in order to keep the production line open whilst ensuring that the TSR.2 force did not have to start to contract from the mid 1970's, perhaps the most likely serial numbers to have been allocated were those actually allocated to the additional Buccaneers procured for the RAF in the wake of TSR.2's cancellation. By slightly stretching the serial numbers allocation actually assigned to the Buccaneers to make use of otherwise unused serial numbers in the same blocks a total of 59 additional TSR.2s could have received serial numbers XW520 – XW550, XX881 – XX901 and XZ427 – XZ435. This would meet the total requirement of 158 aircraft which resulted from the adoption of the Spotswood Report.

A&AEE

The function of A&AEE was the evaluation of aircraft, their armament and other equipment for Britain's armed forces. TSR.2 would therefore have been extensively flown by the A&AEE in order to obtain its Certificate of Airworthiness and service clearance releases both for its airframe and weapons.

Airframe clearances

To obtain the necessary clearances for release to the RAF, A&AEE would have had to continuously expand the envelope in which it was safe to fly the TSR.2 in terms of speed, height, angle of bank, rate of roll, payload etc. Part of this testing would almost certainly have involved the use of TSR.2's short-field capability which was aided by the extendible nose wheel leg, increasing the angle of attack from the beginning of the take-off run thus reducing the distance needed to get TSR.2 into the air.

Allied to the requirement for a short take-off run was that for a short landing run. For the TSR.2 as designed, this normally involved the use of a breaking parachute or in case of emergency, fibre 'crash barriers' similar to the type used on aircraft carriers prior to the advent of the angled deck. The use of such barriers was considered both dangerous and expensive in terms of possible damage to both aircraft and crew by the Air Ministry and this led to the suggestion that an arrester hook might be fitted to TSR.2. In order for this to be used on dispersed airfields it was also suggested that an air portable arrester gear might be developed which would give TSR.2 an excellent short landing capability. The cost of fitting an arrester hook during production was estimated at £1,500 per aircraft and £7,500 as a retrofit modification.

A further series of airframe clearances would have involved operating TSR.2 with its overload fuel tanks. TSR.2 was ultimately capable of carrying two 450 gallon drop tanks mounted at the inboard stores stations under the wings and a non-jettisonable 570 gallon tank in the weapons bay, all of which were capable of being refuelled in the air via the detachable probe fitted to the port side of the nose near the cockpit. The bomb bay tank was principally intended to be fitted for ferry flights, but it was also considered to be of some use operationally in some configurations.

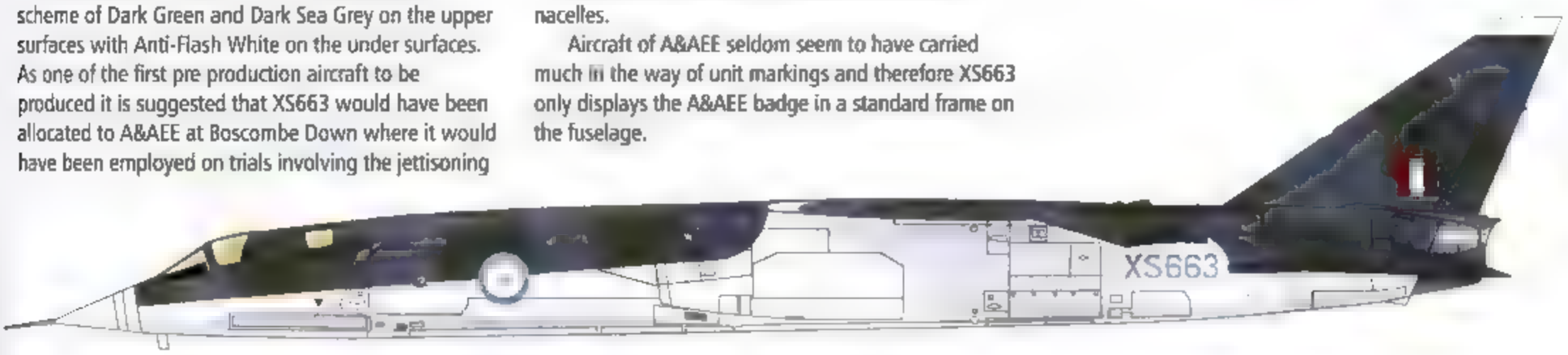
In July 1963 a proposal was made to fit either a 1,000 gallon or a 1,425 gallon ventral drop tank carried under the fuselage on the outside of the weapons bay. Whilst the wing tanks were suitable for subsonic flight only, with a limiting speed of 0.9M, it is thought that the ventral drop tank would be capable of supersonic flight. If jettisoned when empty, the 1,425 gallon ventral tank would extend TSR.2's range by 280 nautical miles but if retained throughout this figure fell to 195 nautical miles.

In March 1965 a further requirement emerged for overload fuel tanks for ferry purposes which would be carried on the inboard store stations. Whether these would have been related in any way to the overload wing slipper tanks advocated by BAC in their Airborne Alert proposal of February 1963 as described previously is not known.

XS663 of A&AEE as it might have appeared in 1968

XS663 was one of the pre production aircraft which might have been finished in the Preliminary BAC scheme of Dark Green and Dark Sea Grey on the upper surfaces with Anti-Flash White on the under surfaces. As one of the first pre production aircraft to be produced it is suggested that XS663 would have been allocated to A&AEE at Boscombe Down where it would have been employed on trials involving the jettisoning or dropping of under wing stores. Therefore XS663 has been shown with a camera fairing on its engine nacelles.

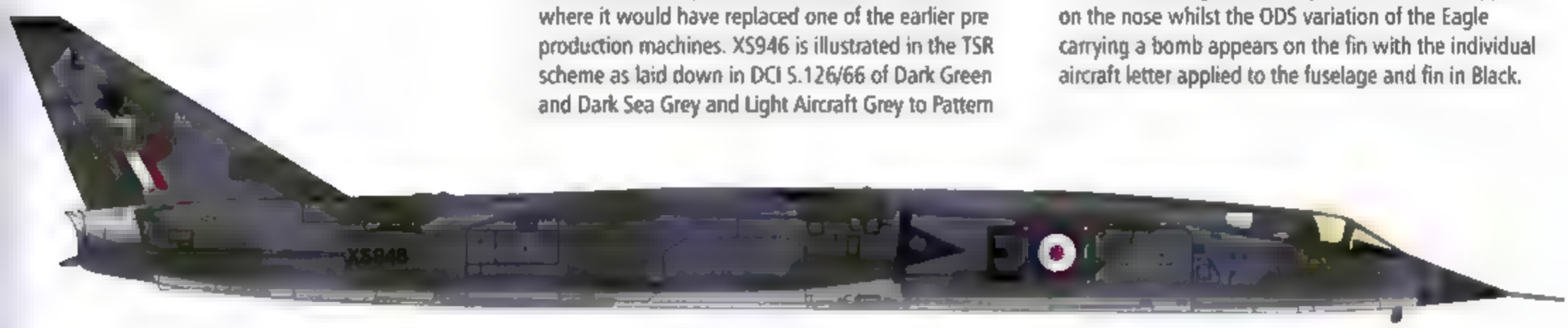
Aircraft of A&AEE seldom seem to have carried much in the way of unit markings and therefore XS663 only displays the A&AEE badge in a standard frame on the fuselage.



XS946 coded 'E' of the ODS as it might have appeared in 1969

XS946 would have been one of the first full production TSR2s expected to be produced during 1969 and would presumably have been allocated to the ODS where it would have replaced one of the earlier pre production machines. XS946 is illustrated in the TSR scheme as laid down in DCI S.126/66 of Dark Green and Dark Sea Grey and Light Aircraft Grey to Pattern No.1 applied using high gloss polyurethane materials to DTD 5580A.

The TSE badge flanked by the ODS colours appear on the nose whilst the ODS variation of the Eagle carrying a bomb appears on the fin with the individual aircraft letter applied to the fuselage and fin in Black.



XS667 coded 'B' of 237 OCU as it might have appeared in 1969

As one of the last pre production TSR2s to be produced in 1968, it is suggested that XS667 would have originally been allocated to the ODS. However, when the ODS began to receive full production aircraft it is suggested that it might have passed a number of its pre production aircraft over to 237 OCU to allow the OCU to begin flying and working up at the earliest opportunity.

Therefore XS667 is illustrated with the remnants of its ODS markings in the form of the individual aircraft letter 'B' still in the pale blue employed by the ODS for this purpose and the TSE badge on the nose. This badge is now flanked by the OCU colours however, and the Eagle on the fin has been modified to wear a mortar board and clutch a scroll in its talons.

XS978 coded 'K' of 237 OCU as it might have appeared in 1970

XS978 falls into the middle of the first batch of 25 full production TSR2s which were expected to be produced during 1969 and is therefore illustrated in the TSR scheme as laid down in DCI S.126/66 of Dark Green and Dark Sea Grey and Light Aircraft Grey to Pattern No.1 using high gloss polyurethane materials to DTD 5580A.

As a full production aircraft, XS978 has a black pigmented radome and aerial covers along with the shock cone and intake lips. The TSE badge is flanked by the 237 OCUs colours on the nose whilst the OCU Eagle with mortar board and scroll appears on the fin. The individual aircraft marking letter 'K' is applied in Black.

XS670 coded 'C' of the Operational Development Squadron as it might have appeared in 1968

XS670 was the last of the pre production batch and would therefore have probably been allocated to the ODS. XS670 is shown in the Preliminary BAC scheme of Dark Green and Dark Sea Grey on the upper surfaces with Anti-Flash White on the under surfaces.

As discussed in the main body of the text, this scheme might have been applied following the initial application of the Anti-Flash White scheme which might have led to the Pale fuselage roundel and Pale Blue serial numbers being retained.

The markings designed for the ODS are based on the basic TSE Eagle design which is now shown carrying a bomb in its talons. The squadron colours are a patriotic red, white and blue arranged in a similar manner to the wartime fin marking but displayed horizontally instead of vertically.

Pale Blue has been selected as the colour for the individual aircraft letter on account of its suitability within the overall scheme and its established use as a marking colour.

Weapons clearances

In October 1963 the Air Staff agreed an informal list of priorities for the weapons release clearances which were required. These were:

1) A single internally-carried WE 177B nuclear weapon delivered by blind laydown at 0.9M from an altitude of 200 feet.
2) A single internally-carried 2,100lb H.C. No.2 nuclear weapon (i.e. the US Mk 48) delivered by blind laydown at 0.95M from between 200 and 500 ft.
3) A single internally carried 2,100lb H.C. No.2 (i.e. the US Mk 48) delivered by lofting at 30, 65 and 110 degrees starting at .90M and 200 feet.
4) Six 28lb practice bombs carried internally and delivered by blind laydown at 0.9 Mach from an altitude of 200 feet and lofted at 30, 65 and 110 degrees starting at .90M and 200 feet.
5) Weapon Simulator Type 105 to simulate practice bomb delivery as given previously. It is not entirely clear what this device was. It was possibly some kind of electronic simulation which did not actually involve dropping a practice bomb.
6) Six 1,000lb HE bombs carried internally and delivered in a shallow dive of up to 30 degrees at speeds of up to 350–550 knots both by stick and salvo at low level.
7) Six internally carried 28lb practice bombs delivered in the same way as the six 1,000lb HE bombs.

Numbers 8 through 13 concerned extending the clearance of the two nuclear weapons already mentioned through the flight envelope with external carriage and increased airspeeds at medium altitude such as 1.7M at 25,000ft.

14) Four 1,000lb HE bombs carried externally and delivered in a shallow dive of up to 30 degrees at speeds of up to 350–550 knots in all release options at low level.
15) Four Matra/ Thomas French rocket pods carried externally and fired in a shallow dive of up to 30 degrees at speeds of up to 350 – 550 knots.

Numbers 16 to 19 inclusive were further clearances with the nuclear weapons and Weapons Simulator Type 105.

Number 20 regarded the carriage of 4 Air-to-Surface missiles to Air Staff Requirement 1168 carried externally, number 21 was concerned with the carriage of 10 retarded 1,000lb HE bombs to Air Staff Target (AST) 1194 both internally and externally whilst number 22 concerned the carriage of 4 bomblet dispensers to AST 1197 externally. Because none of these last three weapons existed at this time the heights and speeds of their delivery was to be determined later.

As can be seen from this list, the Air Staff's priority was to have TSR.2 cleared for a limited nuclear strike role as soon as possible. The initial Certificate of Airworthiness release was planned for October 1966 with full CA release planned for October 1967. All the weapons mentioned above as well as the other proposed payloads for TSR.2 will be described in some detail in the following chapters.

Once A&AEE had completed the necessary testing it was intended that the RAF would receive the final six pre-production aircraft, XS665-XS670. These would be allocated to what in May 1963 was termed the 'Initial Squadron' which would start to operate in 1966. It was intended that this Initial Squadron would form in Bomber Command and would be used to train both aircrew and ground staff who would then go on to form the OCU whilst also developing an operational doctrine for the TSR.2 force as a whole, having a limited CA release for Strike operations from the second quarter of 1966.

By the end of May 1964 the plan for the initial deployment of the TSR.2 had been refined. The proposal in the Spotswood Report that TSR.2 should not be based in Germany appears to have been quickly adopted as on 14 April 1964 the newly reconstituted Ministry of Defence (MoD) which now incorporated what had formerly been the Admiralty, War Office and Air Ministry wrote to the AOC in C Bomber Command to inform him that the re-equipment of the

The Lightning T.5 most closely resembled TSR.2 with regard to performance and instrumentation but would have been too expensive to use as a training aircraft on TSR.2 units

Tactical Strike and Reconnaissance Force with the TSR.2 would now commence with Bomber Command instead of RAF Germany. For the purposes of planning the essential technical and domestic services, Bomber Command was to assume that it would receive the 6 pre-production aircraft during 1966 as planned which would form the nucleus of a strike force of 24 aircraft with the build-up to full strength beginning in the first half of 1968. This build-up was originally planned to be concurrent with the progressive rundown of the 24 Valiants assigned to SACEUR based at Marham as at this time the problem with the Valiant's main spar had yet to manifest itself. The reconnaissance version of the TSR.2 was expected to become available in the last quarter of 1968 allowing the Canberra reconnaissance squadron to re-equip by early 1969. Coningsby was confirmed as the first station to equip with the TSR.2 and the 6 pre-production aircraft were to be allotted during the September quarter of 1966 to a unit which by now had been named the Operational Development Squadron (ODS) which was to be stationed there.

Operational Development Squadron

As envisaged in August 1964, the ODS would be commanded by a Wing Commander and would have three flights, ■ Trials and Tactics flight, a Training flight and a Technical flight. The selection of pilots for the ODS was to be made from Qualified Flying Instructors (jet aircraft) with ■ least one operational jet tour behind them. The selection of aircrew was not to be restricted to any one role and it was intended that the ODS would contain aircrews with a range of experience drawn from the V-Bomber, Light Bomber, Fighter/Ground Attack and Tactical Reconnaissance squadrons.

The 9 ODU aircrews' first task would be to train the instructor crews for the OCU and establish operating procedures whilst investigating and solving problems likely to be encountered in operating the TSR.2 in front line squadrons. The ODS would then complete a full evaluation of the TSR.2 weapons system before as-

Specially modified two seat Hunters powered by the large bore Avon of the F.6 were to be provided as trainers for would be TSR.2 air crew

Expanse would also have been a factor in the provision of a sufficient number of Gnats

suming the identity of an operational squadron with a limited CA release for Strike operations.

In order for this latter task to be accomplished, it was decided that the first 6 full production aircraft (XS944-XS949) should be allocated to the ODS at which time it would assume the identity of an operational squadron. The number plate which was selected on or about 16 August 1963 for this operational squadron was that of 40 Sqn which at that time was allocated for the use of Bomber Command, who had kept the number vacant as part of its contingency planning should an extra squadron number plate be needed.

It was intended that 40 Sqn would remain at Coningsby until December 1968 when its existing six aircraft would move to Marham where they would be joined by six further production aircraft to form the first true operational TSR.2 squadron, apparently adopting a new number plate in the process.

The ODS was to have a fixed life because it was thought that this would be the most efficient and economical way of evaluating an aircraft as expensive and complicated as TSR.2. It was thought that if the life of the squadron was not fixed in this way then the squadron established for a development task was likely to have that task extended indefinitely. It was recommended that after the ODS had completed the introduction trials, that any further trials should be carried out by project teams attached to operational squadrons for the duration of the trials.

237 Operational Conversion Unit

As part of the planning process for the introduction to service of TSR.2, in May 1963 the requirement for a number plate for the TSR.2 OCU came up for discussion. At that time, it was planned that all three of the existing Bomber Command OCUs (Nos. 230, 231 and 232) would remain in existence after March 1968 and therefore a new number plate would be required for the TSR.2 OCU. After some discussion, in June 1963 it was decided that 237 OCU should be the number plate for the TSR 2 OCU on account of its previous history as a Canberra OCU in No. 3 Group Bomber Command based at Wyton between October 1956 and November 1958. Coningsby was also to be the home of 237 OCU which would, once established, carry 12 Hunter T.66s and possibly as many as 17 TSR.2s on its strength in two squadrons, Basic and Applied.

237 OCU Hunter T.66s

The use of this designation in Air Ministry files during the 1963-64 period with reference to 237 OCU would appear to indicate that it was intended to equip the OCU with a service version of Hawker's two-seat Hunter demonstrator G-APUX which ultimately received the designation Mk 66A. This had been constructed from the centre and rear fuselage of an ex-Belgian Hunter Mk 6 which meant that unlike the Hunter T Mk 7 in British service it was powered by the more powerful 'large bore' Avon of the F.6.

Whilst in terms of performance and instrumentation, the Lightning more closely resembled the TSR.2, the provision of the necessary number of Lightnings would have been very costly and this factor also applied, though to a lesser degree, to the Gnat. The Hunter was therefore chosen as a number of surplus F.6s were readily available and their modification into 2 seater aircraft including similar pilot instrumentation to TSR.2 was a much more economic proposition.

One such conversion was actually carried out on XE531 which had started life as an F.6 before conversion to FGA.9 standard. In addition to the new two-seat forward fuselage XE531 was fitted with a Head Up Display and vertical camera in the nose, the intention being that XE531 could not only be used for trials of various avionics systems for TSR.2 but also as a prototype for future conversions which would equip the TSR.2 OCU and front line squadrons.

It was intended that the first 6 Hunter F.6s would be made available for modification in the June quarter of 1966 and that besides the OCU requirement each operational TSR.2 squadron should have two Hunters. Some files dealing with this matter refer to the two-seat large bore Hunter for RAF service as the Mk T.7A but XE531 was designated as the Hunter Mk 12 and it is therefore possible that this is the designation these Hunters would have received had they entered service. No serial number allocations for the Hunter T.12 are known as the conversions were never carried out.

Subsequently, the only T.12, XE531 served with the RAE at Farnborough for many years after TSR.2 was cancelled whilst the Mk 66 became an export version supplied to Jordan, Lebanon, India, Kuwait and Iraq.

The Hunter squadron was to provide lead-in for high-speed low-level and weapons training for both pilots and navigators. At that time, navigators were generally experienced in flying high and fast, or low and slow. Because comparatively few navigators were experienced in flying low and fast, it was thought that experience of such flying in the Hunters would be beneficial whilst also giving them a better appreciation of the pilot's problems in a high-speed, low-level environment.

237 OCU TSR.2s

The TSR.2 squadron was to produce aircrews for the operational squadrons. At this time it was RAF practice to train its aircrews up to a certain point in the OCUs leaving the final training which made an aircrew 'combat ready' to the operational squadron to which they were posted. Thus whilst the number of operational squadrons remained constant, their operational effectiveness was open to question as not all their crews were combat ready and much time and effort was spent by the squadrons making them so which might have been better spent honing the cutting edge.

By the mid 1960s, this practice was becoming more difficult to justify on grounds of cost if nothing else and with the introduction of the enormously expensive and complex TSR.2 pending this practice was reviewed. It would appear that at one point some consideration was given to adopting the Royal Navy practice of firstly establishing a squadron as a training squadron and working the squadron up to operational effectiveness as a whole before declaring it to be operational. Once declared operational, the squadron would then exist for a period of three years or so before disbanding to have its place taken in the front line by a replacement squadron.

This idea however was perhaps a little too radical for the Air Ministry to adopt and it was ultimately decided that TSR.2 crews would be fully trained within the OCU and be combat ready on posting to the TSR.2 squadrons.

It was envisaged that 4 crews would transfer from the ODS to found the OCU whose aircraft were expected to arrive in the June quarter of 1967. Planned deliveries to the OCU were 8 TSR.2s by December 1967 rising to a total of 12 by June 1968 with a full complement of 17 TSR.2s by June 1969. The OCU would take 6 crews every 6 weeks for a 40-week course with the OCU's output being expected to rise gradually as its aircraft were delivered to a peak of between 45 and 50 crews per year. The flying syllabus at the OCU was to consist of some 60 hours for second tourists whilst first tourists were to complete 70 hours, of which one third

XS949 coded 'A' of 40 Sqn as it might have appeared in 1969

XS949 was one of the first full production TSR2s which were expected to be delivered in 1969. It has therefore been illustrated in the TSR scheme as laid down in DCI S.126/66 of Dark Green and Dark Sea Grey on the upper surfaces and Light Aircraft Grey under surfaces to Pattern No.1. All these colours would probably have been high gloss polyurethane to DTD 5580A. So as to be more in keeping with the camouflage finish the radome and aerial covers have been pigmented black during manufacture.

The shock cones and intake lips have been shown as being coloured black as it has been suggested that the shock cone and intake lip of production aircraft would have been electrically heated. An alternative explanation might be that these areas were treated with a special finish to reduce the radar cross section of the aircraft. This latter possibility is mentioned in Chapter 8.

40 Sqns markings consist of the squadrons broom badge which is applied ■ the fin on a White circular field which has a pale blue outline as sanctioned by the marking DCI's of the period. The broom is repeated on the nose inside a standard frame where it is flanked by squadron colours.

The only colours known to have been used by 40 Sqn are yellow and blue used in a chequer pattern which they shared with 100 Sqn when both squadrons were flying Canberras based ■ Wittering in the mid 1950s. This chequer pattern is thought to have originally been a Wittering Station marking but because 100 Sqn remained active following 40 Sqns disbandment in December 1956, 100 Sqn was able to make the blue and yellow chequer marking its own and it continues in use on 100 Sqns Hawks today. Consequently the counterfactual TSR2 equipped 40 Sqn would be unable to use this design and a yellow, blue yellow marking inspired by 23 Sqns markings have been applied instead.

The Jet Provost provided side-by-side Ab-initio training for RAF pilots during the 60's and 70's

was to consist of dual instruction.

The last three weeks of the OCU course might have taken the form of advanced training at an overseas training base. Though no final decision is known to have been taken on the location of the overseas training base, Goose Bay was mentioned in this context as being suitable for European based crews. NEAF and FEAF were expected to provide their own training in-Theatre to meet local conditions. Wastage was estimated at 10 percent in training and 7 percent on the squadrons.

Dual-control TSR.2

A major problem in the TSR.2 training programme was seen as the high proportion of first tour pilots who would have to be accepted into the TSR.2 force direct from Flying Training School from 1969 onwards. Bomber Command, RAF Germany, NEAF, FEAF, A&AEE and ETPS were all agreed that a dual version of TSR.2 was essential for the initial conversion of such inexperienced pilots who even allowing for lead-in training on the Hunter would begin their conversion to the TSR.2 with no more than 300 hours in their log books.

In the past it had often been Air Staff policy to provide a dual version of some types of aircraft and whilst some of these had gone into service some considerable time after the operational version, subsequent experience had fully justified the policy. In the case of the TSR.2 it was considered that the cost of producing the dual version would be more than offset by the reduction of the risk of accidents resulting from pilot error, particularly at the OCU.

After a careful study of the TSR.2 and its characteristics the Air Staff initially asked that a dual-control version of the TSR.2 be provided which featured side-by-side seating as found in the Jet Provost and Lightning T.4. The dual TSR.2 could then be used to carry out instruction and standardisation checks in both basic flying and operational techniques, including weapons delivery.

In the event, the requirement for side-by-side seating had to be abandoned for several reasons. Firstly, major modifications would have been necessary to the basic design and these would have imposed major research and development costs. Secondly, these modifications would also have diverted significant amounts of design and engineering effort from the operational aircraft thus delaying its entry into service. Finally, the major changes to the fuselage might have reduced the performance of the trainer version so much that it might no longer have been representative of the operational aircraft and would not have been readily convertible to full operational standard.

In place of the side-by-side seating arrangement, it was proposed that the training requirement might be met by a tandem-seating arrangement based on the operational version whereby a conversion kit would enable any operational TSR.2 to be used as a trainer. It was recognised that this would not be an satisfactory a solution to the problem of pilot training as the original proposal, but it was thought that this arrangement would provide an aircraft in which the instructor could demonstrate and monitor take-off, approach and landing, and certain basic operational manoeuvres such as the Low Altitude Bombing System and dive bombing techniques but without actually aiming or releasing a weapon. The TSR.2's weapons systems would however remain fitted to the aircraft which was only to be modified to the extent that the instructor could exercise the function of first pilot and captain from the rear seat.

A project study to this end was carried out with a budget of £50,000 which was used to produce a mock-up of the proposed dual trainer. The principle modifications consisted of removing the original canopies and some of the surrounding structure and fitting a one-piece clear canopy, raising of the rear seat by some 7 inches above the normal navigator's position measured along the ejection path, a new instrument panel, the appropriate flying controls and a periscope which projected through the bottom of the fuselage.

It was envisaged that besides the dual aircraft required by the OCU, a dual TSR.2 would be provided for each squadron. However

The Lightning T.4 was an outstandingly successful example of Air Staff policy of providing a dual version of a front line aircraft type

Hunter T.12 XG204 coded 'T' of 237 OCU as it might have appeared in 1969

In the real world XG204 was a Hunter F.6 on the strength of the Day Fighter Combat School which disbanded in late 1965. It is suggested that XG204 would therefore have been available for conversion from the June quarter of 1966 to T.12 standard.

In its new role XG204 would have been camouflaged and marked in accordance with DCI 5.126/66 which stated that aircraft used for operational training were to be coloured and finished according to their operational role, in this case Dark Green, Dark Sea Grey and Light Aircraft Grey in high gloss polyurethane.

The markings designed for 237 OCU had their origins in the practice of the real world 237 OCU of utilising a mortar board and crossed cutlasses as its badge. The mortar board signifies learning and the crossed cutlasses are a reference to the aircraft type flown, the Buccaneer and its maritime associations.

The counterfactual TSR2 237 OCU badge therefore consists of the TSE Eagle wearing a mortar board and clutching a diploma in its talons. The squadron colours are a red, light blue and dark blue arrangement based on the established Officers Rank Pennant designs intended to reflect the leadership role of the TSE and OCU for the TSR2 force as a whole.

In the real world, XG204 finished its days on the strength of 4 FTS at Valley in July 1969 when it was lost in a fatal accident.

it was ultimately agreed, albeit reluctantly, that in the interest of economy that this would not be possible. In May 1963 it was therefore planned that 7 dual TSR.2s would be in use at the OCU which would be backed up by a further 2 aircraft and conversion kits which would be retained in the operational configuration until needed. In addition to this, the Air Ministry wished that a further 16 aircraft should be convertible to the trainer role should the need arise. The operational squadrons would have to rely on Hunter T.12 trainers and simulators backed up by regular visits from a standardisation team from the OCU who would bring a dual TSR.2 with them.

The mock-up of BAC's proposed dual conversion was examined in January 1965 by a flying instructor from the RAF Handling Squadron who had logged more than 1,000 hours instructing from the rear seat of the Meteor T.7, Javelin T.3 and Gnat. He concluded that in the conditions shown in the mock-up, an approach and landing would be extremely difficult and probably hazardous if not impossible due to the lack of forward visibility from the rear seat when the aircraft was in the nose-up position.

In a letter to the Directorate of Operational Requirements dated 17 March 1965 the Director of Flying Training stated his view that the present BAC proposals for the dual TSR.2 did not meet the training requirement. It now appeared obvious that BAC could not meet the requirement whilst satisfying the RAF requirement that the training aircraft should be capable of conversion back to the strike role. The solution to this dilemma was to abandon the idea of conversion and initiate a new design study to produce a dedicated training version. In doing this it was accepted that there would probably be penalties in performance but it was considered that a dual TSR.2 would be capable of fulfilling its design task within the limits of 450 knots indicated airspeed, a maximum Mach number of 1.4 and a maximum altitude of 40,000ft. With these figures in mind it was thought that it would not be insurmountably difficult to fit a larger, perhaps bulged, two-piece canopy on the aircraft.

As things stood there appeared to be two alternatives, a) to redesign the dual TSR.2 or b) to eliminate the requirement, an option about which the DFT had the deepest misgivings. Whilst the DFT was strongly in favour of having another look at the problem, this was as far as the dual TSR.2 ever got as the whole programme was cancelled less than a week later.

The Tactical Strike Establishment

With both the ODS and OCU to share the same base at Coningsby, it was suggested that the Coningsby organisation as a whole should be known as the Tactical Strike Establishment (TSE) and be commanded by an Air Commodore. The aims of the TSE were to:

a) Develop the techniques for the use of TSR.2 in limited and global war.
b) Evaluate the TSR.2 weapon system and to study and develop techniques for its use in all theatres.
c) Study the problems peculiar to overseas reinforcement by the TSR.2 and to develop techniques involving flight refuelling.
d) To train aircrews at the TSR.2 OCU in the efficient use of the weapons system.
e) To train Navigation and Attack systems technicians for all TSR.2 units.

In the pursuit of these aims the TSE was to maintain a close liaison with RAF Commands at home and overseas and with Commonwealth and Allied forces on all aspects of TSR.2 operations.

Slippage and problems

As has already been mentioned, the in-service date of TSR.2 slipped and by January 1965 the plans for the formation of the ODS had also slipped so that it was now intended to form the unit in April 1967. A number of other problems then emerged surrounding the allocation of the pre-production aircraft to the RAF which appeared to indicate that the ODS could not form until June 1967 and the build-up would then proceed more slowly than intended with only four aircraft being received by the end of 1967. By June A&AEE should have been able to give a special training clearance up to 450 knots between altitudes of 1,000 and 35,000ft. Even then, the rate of roll would be severely restricted with 25 degree banked turns being the maximum allowed. Nevertheless, it was felt that even with these restrictions in place, some degree of worthwhile pilot training could be carried out.

The Navigation and Attack system would not be functional however and this posed problems for the training of the navigators who were intended to go on to become the instructors at the OCU. This, taken with the very limited nature of the initial clearance from A&AEE suggested that it was premature to set up the ODS in June 1967 as an independent unit. Thus it appeared that the plan for the formation of the ODS might need to be revised and it was suggested that the ODS form in two distinct phases.

The first phase would be to post the first ODS aircrew along with two aircraft and servicing teams at Boscombe Down where, whilst being autonomous and under the control of Bomber Command, it would be able to take advantage of the A&AEE's experience on the type. Initially basing the ODS at Boscombe Down would also allow the navigators to participate in the development phase of the Navigation and Attack system and thus provide them with the experience they would need to become instructors at the OCU as quickly as possible. The precedent for this had been set by Transport Command crews flying in manufacturers' development aircraft from an early stage which had proven to be highly beneficial in introducing new types to service. An added benefit was that by basing the unit at Boscombe Down, the availability of aircraft for service flying might be eased.

The second phase was to redeploy the ODS to Coningsby en bloc after two or three months.

Camouflage for production TSR.2s

In February 1963 the Directorate of Operational Requirements raised the question as to whether the external finish of the TSR.2 could be a colour other than white, with light grey apparently being suggested as a study was already under way to consider the possibility of camouflaging the V-Bombers.

Despite the provisions of AMO A.239 dated 23 November 1960 which stated that TSR aircraft were to be camouflaged, it would appear that it was originally thought that TSR.2 should be coloured Anti-Flash White to give maximum protection from weapon flash heating in its nuclear strike role.

However, it would appear that a change of thinking had come about as a result of the need in the post-Skybolt era to penetrate Soviet airspace at low level and the Air Staff had stated that camouflage was required for the upper surface of the V-Bombers. As a result of this, in order to give a reasonable camouflage against visual interception throughout the year the upper surfaces of the V-Bombers were coloured in a variegated pattern of grey and dark green whilst retaining the standard Anti-Flash White under surfaces despite the resultant loss in anti-flash protection (figures given in November 1963 for heat absorption of Anti-Flash White of 25 percent contrast with the figure of 85 percent for the then current camouflage) as camouflage was considered more important than anti-flash protection to enable the aircraft to reach its target unobserved.

A suggestion was made that it might be possible to develop a camouflage paint which might have an absorption figure of between 40-45 percent but this proposal ultimately came to nothing as studies indicated that in a full nuclear exchange the aircraft was more at risk from blast overpressure than the heat generated by the explosions and that the aircraft would disintegrate before it burned. It was therefore concluded that standard camouflage

paint would be adequate protection for the V-Bombers.

By May 1964 no firm decision as to the finish of production TSR.2 had been made. On 21 May the DOR once again raised the question of the colour scheme of the TSR.2 in a Loose Minute circulated within the Air Ministry. The memo stated that at present TSR.2s were being finished in white which might be thought too conspicuous a colour for a tactical strike aircraft as the white finish increased the vulnerability of the aircraft when parked on the ground and increased the risk of interception in flight. It was thought that the ideal colouring would provide camouflage for these cases whilst at the same time rendering the task of a visually aimed Surface-to-Air Missile (SAM) of the 'Redeye' type more difficult.

It was noted that studies carried out into the vulnerability of the TSR.2 to damage from one of its own nuclear weapons was approximately the same as a V-Bomber and as V-Bombers were now camouflaged it seemed likely that the TSR.2 could also be camouflaged in the same way without significantly increasing the risk of damage. It was therefore requested that the operational colouring for the TSR.2 now be decided and a copy of the then current NATO Standardisation Agreement (STANAG) for Light/Strike, Medium and Heavy Bombers was appended along with a colour photograph showing a white and camouflaged Vulcan flying in formation at low level to illustrate the contrast between the two finishes.

As far as the TSR.2 was concerned the STANAG agreed with the provisions of AMO A. 239/60 in that it stated that Light Bomber/Strike Aircraft were to have their upper surfaces finished in a camouflage pattern of Dark Green and Dark Sea Grey whilst their under surfaces were to be Silver.

By 14 July 1964 a consensus of opinion within the Air Ministry had emerged that the colouring scheme in NATO STANAG 3085 for Strike aircraft should be adopted and on 25 August 1964 the Air Ministry requested that the Ministry of Aviation advise BAC accordingly and that this scheme was to be adopted as soon as possible and not later than the tenth pre-production aircraft.

Works Diagram

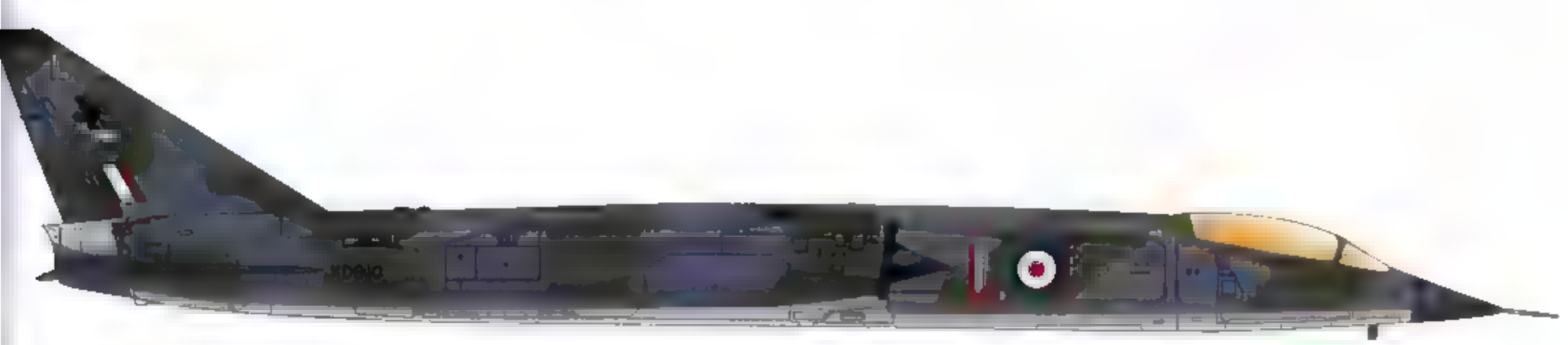
In response to the requirement for TSR.2 to be camouflaged BAC Weybridge Division Drawing Number 57900 Sheet 11A was drawn up on or about 24 November 1964. Stamped 'Preliminary', this diagram showed the disruptive pattern which was to be applied to the upper surfaces in Dark Green and Dark Sea Grey. The upper surface colours were to be extended around the wing and tailplane leading edges and back inside the lip of the air intakes for a distance of 6 inches. At this stage, the under surfaces were to have remained White with the boundary between the upper surfaces and under surfaces following the centreline of the fuselage when viewed from the side elevation, and being curved upwards and downwards to meet the trailing edges of the mainplane and tailplane roots.

This form of boundary, falling half way between the traditional Pattern No. 1 and Pattern No. 2 demarcations, appears to have been based on the Second World War Night Fighter scheme and was introduced for night ground attack aircraft by AMO A. 265/54 following which it was applied to the Canberra B(I).8. This boundary was also employed on the first Victor to receive camouflage in early 1964 before a more traditional Pattern No. 1 was adopted across the whole of the V-Force. Why this demarcation between the upper and under surfaces was chosen by BAC is unknown but may be related in some way to the Canberra B(I).8 scheme.

The retention of white on the under surfaces when both the STANAG and AMO call for TSR aircraft to have silver under surfaces is possibly the result of one of two factors. The first of these harks back to the debate on the colour of the TSR.2 mentioned above which had taken place during the summer of 1964. During the deliberations on a suitable camouflage finish for the under surfaces, there had been a school of thought which considered that as the likelihood of hiding a low-flying aircraft from a ground observer who was within visual range was remote, the under surfaces should be painted in the best colour to provide thermal protection in the event of high level operations and that this appeared to be white.

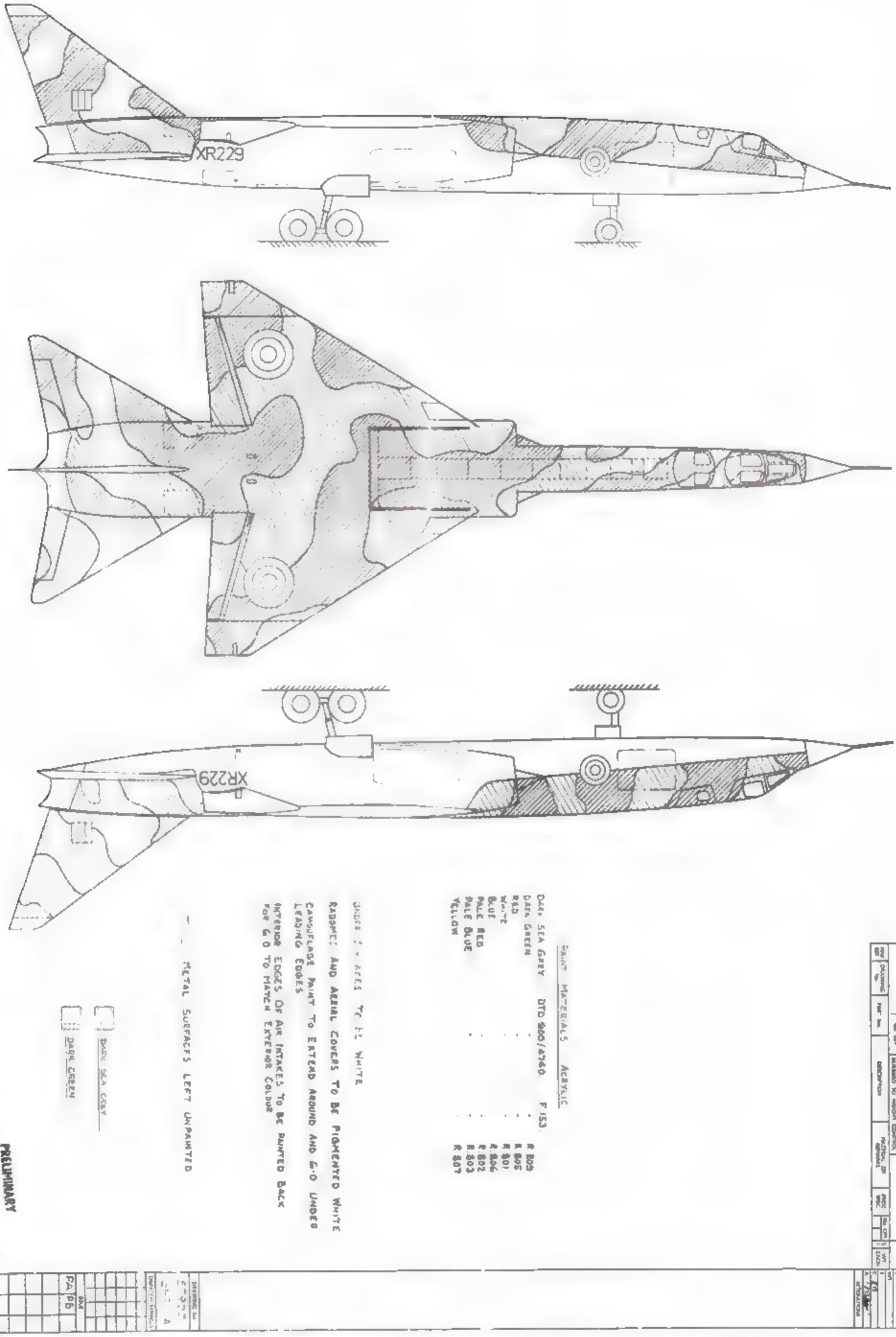
The second factor possibly lies in the chemistry of the paints being used by the RAF at this time. Though the BAC camouflage drawing refers to DTD 900/4740 Acrylic, as mentioned previously, a service trial of an acrylic finish on two Valiants had been considered a failure so it is by no means certain that this material would have been applied to production TSR.2s. During the early 1960s the current paint finish employed on RAF aircraft was DTD Specification 5555 Exterior Glossy Finishing Schemes (cold curing epoxide type) which had been introduced from June 1959. However by 1964 this finish was beginning to be superseded by an entirely new material, DTD 5580 Cold Cure Polyurethane. This type of paint was found to be much more hard wearing than previous types of paint and began to be introduced in the full range of aircraft colours used by the RAF. However, for some reason involving the chemistry of the paint, it proved impossible to formulate a polyurethane paint to give a silver finish.

Though Acrylic DTD 900/4740 is to be found in the 1965 edition of AP 1086 RAF Vocabulary of Stores Section 33B, it appears to have fallen from use by the early 1970's. Documents which deal



XV910 coded 'L' of 237 OCU as it might have appeared in 1971

XV910 represents one of the 9 TSR.2s which were to be modified into pilot training aircraft with the specially modified canopy which would have allowed an improved view for the instructor pilot in the rear seat. Whether such a non operational aircraft would have been treated with the gold film which is thought to have been radar camouflage for the cockpit might be open to question, but it has been shown as being so on the following grounds. Firstly, it might have been considered necessary to acclimatise the trainee to looking at the world through the gold tinted canopy which would be encountered on an operational TSR.2 and secondly, the possibility that even the pilot training aircraft might be called upon to fly operationally in an emergency.



TSR.2 Camouflage Parking Pattern, BAC Drawing No 57900 dated 24 November 1964

This diagram shows the proposed disruptive pattern to be applied to the upper surfaces of TSR.2 in Dark Green and Dark Sea Grey. The boundary between the upper and under surfaces is unusual in that it appears to be similar to that specified for Night Ground Attack aircraft in AMO A.265/54 which was applied to the Canberra B(I).8
It is thought possible that this scheme might have been applied to the pre production batch XS660-XS670 to which application of the earlier overall Anti Flash White scheme had already commenced when TSR.2 was cancelled in April 1965.

with the decision to move away from Polyurethane to Acrylics dating from the mid 1970's appear to suggest that the main reasons that an Acrylic finish was not adopted in the mid 1960s were the superiority of the Polyurethane finish in offering protection from Nuclear, Biological and Chemical agents as it was hard wearing and easy to clean in its original gloss form, coupled with an apparent difficulty in obtaining sufficient supplies of Acrylic paint.

In light of the above, DTD 5580 Polyurethane would presumably have been the logical choice of material for production TSR.2s. As silver was not available for use on the under surfaces and with concern continuing about the necessity for some degree of thermal protection to be retained for high level operations, it is possible that white was therefore initially adopted instead.

The possibility therefore exists that a small number of aircraft might have been finished in this scheme, especially those of the pre-production batch XS660-XS670 to which the application of the Anti-Flash White scheme had already commenced, but it is the author's opinion that by the time production aircraft would have been ready for service, they would have conformed to the then current RAF camouflage and marking requirements.

Defence Council Instructions

Following the amalgamation of the three service Ministries, the Admiralty, War Office and Air Ministry within the Ministry of Defence in 1964 the old method of promulgating changes in camouflage and marking policy to the RAF via Air Ministry Orders came to an end. The Air Ministry Order was replaced by Defence Council Instructions (RAF) (referred to henceforward as DCIs). The replacement of High Speed Silver with Light Aircraft Grey as an undersurface colour appears to have been promulgated to the service as part of DCI T. 346/65 dated 4 August 1965. This was only a temporary instruction, and it was soon replaced by a standing DCI, S.126 dated 10 August 1966 which then remained in force until August 1969 and would, therefore have spanned the TSR.2's introduction to service.

DCI S.126/66 Camouflage and Markings

As far as the TSR.2 in the strike role is concerned, DCI S.126/66 stated that Tactical Strike aircraft were to be painted in the disruptive camouflage pattern shown in AP 2656A Volume 1 section 4 where the shaded areas of the diagram were to be painted in Dark Sea Grey and the unshaded areas were to be Dark Green. This however was only a general instruction as the diagram in question showed a Hunter whose disruptive pattern was nothing like that to have been applied to TSR.2 as illustrated in the BAC diagram.

The under surface of the fuselage, mainplanes and tailplanes were to be "light grey Colour 9-095 /British Standard 2660". It is thought that this colour was adopted because at that time it was impossible to manufacture an aluminium pigmented Polyurethane aircraft paint which gave a silver finish and BS 2660 9-095 was the closest British Standard colour to silver.

Aircraft which were to be used for operational training such as the Hunter T.12s and TSR.2s of 237 OCU were to be coloured and finished according to their operational role i.e. Dark Green, Dark Sea Grey and Light Aircraft Grey.

British Standard colours

Since 1939 British aircraft camouflage standards had been issued by a variety of different bodies. The Air Ministry issued the first set of camouflage colour standards in 1939 following which responsibility for colour standards was taken over first by the Ministry of Aircraft Production and from 1946 the Ministry of Supply. By 1957, the Ministry of Supply aircraft finishes were issued in a small ring binder which was a supplement to BS 381C.

BS 381C

BS 381 was originally published in 1930 and subsequently revised as BS 381C in 1948. The 1948 edition then remained in use until the Standard was revised again in 1964 as BS 381C :1964 Colours for Specific Purposes. The 1964 edition brought together in one Standard colours which various public bodies, utilities, industry and HM Services required for identification or technical purposes based on long established practice, and amongst the colours introduced to the new edition were some of those contained in the Ministry of Supply HMG Aircraft series supplement to BS 381C referred to above. Thus it is from this point onwards that BS 381C begins to be quoted in connection with aircraft camouflage.

The colour reference from BS 381C is made up of two components, the reference number and the colour name. The reference numbers divide the colours up into seven broad colour divisions, each division having a range of numbers allotted as follows.

100-199 Blues; 200-299 Greens; 300-399 Yellows, Creams and Buffs; 400-499 Browns and Pinks; 500-599 Reds and Oranges; 600-699 Greys and 700-799 Violets. The reference number is the important part of the reference as the colour name can change.

The 1964 edition remained in use with two amendments until 1980 when it was once again revised, and the resulting 1980 edition remained in use until superseded by the 1988 edition and most recently the 1996 edition.

The 1964 edition saw the inclusion of commonly used RAF camouflage colours such as Dark Green which for some reason was misnumbered as BS 381C No. 641 and Dark Sea Grey which became BS 381C No. 638.

BS 2660

As mentioned previously BS 2660 was entitled 'British Standard for Colours for Building and Decorative Paints' and was first introduced in 1955. It remained in use with various amendments until replaced by BS 4800 'Specification for Paint Colours for Building Purposes' in 1972. Colours within BS 2660 did not have names, only reference numbers, so when colour 9-095 was selected for use by the RAF it had to be given an appropriate name. Therefore BS 2660 colour 9-095 was incorporated into BS 381C as No. 627 Light Aircraft Grey as part of Amendment No. 1 to BS 381C (1964) on 30 August 1966.

Markings

Markings fell into one of two categories, being classed as either mandatory or optional. Mandatory markings consisted of roundels and fin flashes, aircraft serials and emergency and warning markings.

Roundels and fin flashes were to be BS 381C No. 538 Post Office Red, White and BS 381C No. 110 Roundel Blue whilst numbers and identification letters were normally to be Black. However, from about 1963 to about 1972 some refurbished RAF Hunters and both refurbished and new-build Buccaneers were marked with their fuselage serial numbers in White. Exactly why this was done is currently unknown. Other new aircraft which were delivered direct from the manufacturers at the time that TSR.2s should have started to be delivered in the late 1960's such as Harriers and Phantoms had their serial numbers applied in Black.

'Break in', 'Walkway', 'Sling', 'No Step' and similar informative markings along with external exit handles were to be BS 381C No.356 Golden Yellow, whilst danger warning signs were to be Post Office Red. Though not specifically mentioned in this DCI, Walkway markings consisted of a Golden Yellow line with a fringe of Post Office Red strips around its outer edge giving a half fish spine effect.

Optional markings were defined as Aircraft Identification and Unit Code markings, Fighter Squadron markings, Unit Badges and Affiliation markings.

Aircraft Identification and Unit Code markings could be applied to distinguish between individual aircraft within a single unit. Authorised by Command headquarters, when more than one letter

Variations in under wing serial number and roundel presentations

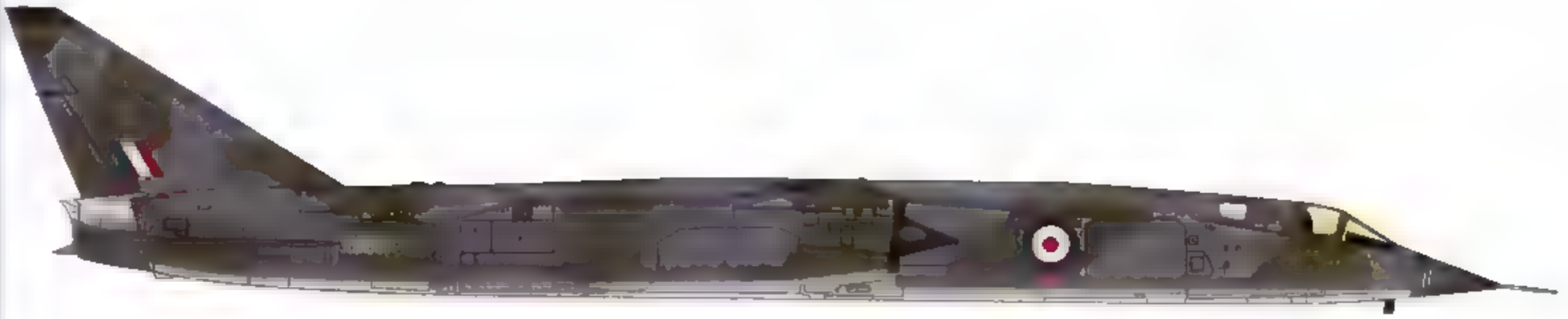
Because it is not known for certain what form the under wing serial number and roundel presentation would have taken, four possibilities are illustrated. The first and in the authors opinion most likely is the presentation shown on the 4 view of XS949 of 40 Sqn which has the characters applied to the under surface of the wings at 90 degrees to the line of flight. This is the style of presentation adopted on other large delta wing types such as the Javelin and Vulcan.

The alternatives illustrated here are:

1) 36 inch characters aligned with the leading edge of the wings in the manner applied to Phantoms and Buccaneers.

2) 30 inch characters swept back slightly in line with the flaps which would keep most of the characters from being interrupted by TSR2s under wing stores pylons.

3) 30 inch characters arranged in a similar manner to that adopted on the Hunter and Harrier.



Alternative fuselage serial presentation

As noted in the main body of text, some RAF aircraft during the late 1960s and early 1970s such as Buccaneers and Hunters carried their 8 inch fuselage serial numbers in White. This might have been the result of an in service repaint and it is therefore possible that some TSR2s might have been given white serial numbers on their fuselages, especially those in the XS660-XS670 pre production batch which might have been repainted from the Preliminary BAC scheme to the TSR scheme as given in DCI S.126/66 by the Service.

was used care was to be taken to ensure that the sequence of the letters was the same from whichever side of the aircraft it was seen.

Fighter squadron markings could be applied on either side of the fuselage roundels of fighter aircraft of squadrons whose markings had been authorised by the MoD.

Unit Badges could be displayed on aircraft in accordance with the provisions of DCI S.13/65 which is dealt with in more detail below.

Affiliation markings concerned units which were affiliated or were otherwise associated by civic honour, and appropriate markings could be displayed as authorised by the MoD.

Variations

Air Officers Commanding or Commanders in Chief were authorised to use additional markings where this was considered essential to meet operational conditions. These might take the form of markings to facilitate recognition in the event of a forced landing in jungle or Arctic areas or to avoid confusion with aircraft of a similar type operated by other nations. The MoD was to be notified of any such variation from standard markings.

One marking variation which was discussed with reference to TSR.2 concerned the question as to whether the dual-control version of TSR.2 would require special training markings in the form of dayglo bands on the wings and fuselage. When BAC raised this issue in September 1964 they were informed by the MoD that such markings would not be required.

Unit markings

The DCIs covering the application of unit markings which ran concurrently with DCI S.126/66 was DCI S.13/65 'Unit Badges on Aircraft and RAF Property' dated 27 January 1965 and DCI S. 223/67 dated 13 December 1967. These instructions stated that unit badges could be placed on aircraft and other RAF property provided that they had been accepted for registration by the MoD (Air Force Department) and the Inspector of RAF Badges and approved by The Queen.

Badges could be applied to aircraft at the discretion of the AOC in C either complete with the standard frame and motto, provided that the overall height did not exceed 18 inches, or without the frame and motto on a circular white background 18 inches in diameter with a half inches border of RAF pale blue.

Anyone who has ever looked at photographs of RAF aircraft will no doubt recognise the general principles given here whilst realising that there was often considerable variation in how these rules were interpreted. It was not uncommon to see Canberras with squadron colours flanking badges applied to the fin, or alternatively to see the colours flanking badges inside standard frames upon the nose of Hunters. Some squadrons even outlined their squadron colours with a thin pale blue line. Such markings could be seen in a variety of sizes, with badges often well in excess of the officially sanctioned 18in One ex-officer responsible for the application of squadron markings to the aircraft of his Hunter squadron freely admitted to the author that he had no idea that such rules existed and simply produced something which looked good!

The Squadron Badge of No.3 Flying Training School set inside a Standard Frame as applied to that units Jet Provost T.4s as authorised by DCI S.13/65

Vocabulary of stores listings

The 1966 edition of AP 1086 RAF Vocabulary of Stores Section 33B lists all of the colours applicable for the camouflage and mandatory markings applied to TSR aircraft as being available to Paint System, cold cured polyurethane to Spec DTD 5580A with the following 33B stores reference numbers for a gloss 15 litre set: Black 33B/2204846; Dark Green 381C/641 33B/2204850; Dark Sea Grey 381C/638 33B/2204853; Light Aircraft Grey 381C/627 33B/2204852; Medium Sea Grey 381C/637 33B/2204854; Post Office Red 381C/538 33B/2204855; Golden Yellow 381/C 356 33B/2204859; Roundel Blue 381C/110 33B/2204848 and White 33B/2204858.

Chapter 5

The Nuclear Strike Role

OPERATIONAL REQUIREMENT OR 343 STATED THAT THE PRIMARY role of the aircraft was to be the effective delivery of tactical nuclear weapons in support of SACEUR and other regional pacts. It was assumed that the targets which would need to be attacked would be heavily protected by integrated Fighter systems and possibly Surface-to-Air Guided Weapons systems, these defences would need to be penetrated for an attack to be carried out. The Air Staff therefore decreed that the carriage and delivery of the nuclear weapons should cause no detriment to the performance of the aircraft. To this end it would be necessary to carry and dispense the nuclear weapons throughout the full flight envelope of the aircraft with an accuracy consummate with the yield of the weapons. Particular importance was attached to the elimination of the need to depart from low-level flight

When the specification to OR 343 which became the TSR.2 was drawn up in 1959 it stated that provision was to be made for the internal carriage of a single tactical nuclear weapon and external carriage of two tactical nuclear weapons. The types of weapon specified were either the weapon which was in the process of being designed to Operational Requirement 1177 or alternatively what the specification refers to as a '1,900lb HE Bomb' which was a euphemism for the US manufactured Mk.28 nuclear bomb expected to be made available to those RAF Strike aircraft assigned to SACEUR under Project E. At the time the specification was written, no hard information appeared to be available on either the OR 1177 weapon or the US Mk.28 and as a result of this, data pertaining to Britain's first tactical nuclear weapon developed to OR 1127 and code named Red Beard was used in the initial design studies instead. This led to the shape of Red Beard being used on some general arrangement drawings of TSR.2 such as the one reproduced on page 128.

Red Beard

Red Beard had been developed to Operational Requirement 1127 to provide both the RAF and Royal Navy with a tactical nuclear weapon capable of being carried by aircraft such as the Canberra, Scimitar and Buccaneer. The resulting device was essentially a scaled-down Blue Danube which was Britain's first nuclear weapon carried by the V-Force, and Red Beard is thought to have entered production and service with the Royal Navy in 1959 before entering service with the RAF in 1961. Once in service it is thought to have provided the Strike armament of the NEAF Canberra Wing on Cyprus and 45 Sqn's Canberra B.15s in FEAF.

Two variants appear to have existed, the Bomb Aircraft HE 2,000lb MC No.1 and the Bomb Aircraft HE 2,000lb MC No.2. Each of these versions had an appropriate drill version for ground training and there was also a Bomb Aircraft Practice (inert) 2,000lb MC which is thought to have been used for practice bombing. The difference between the two different live versions of Red Beard is currently unknown but both are thought to have been the subject of a proposed modification to the shape of the nose.

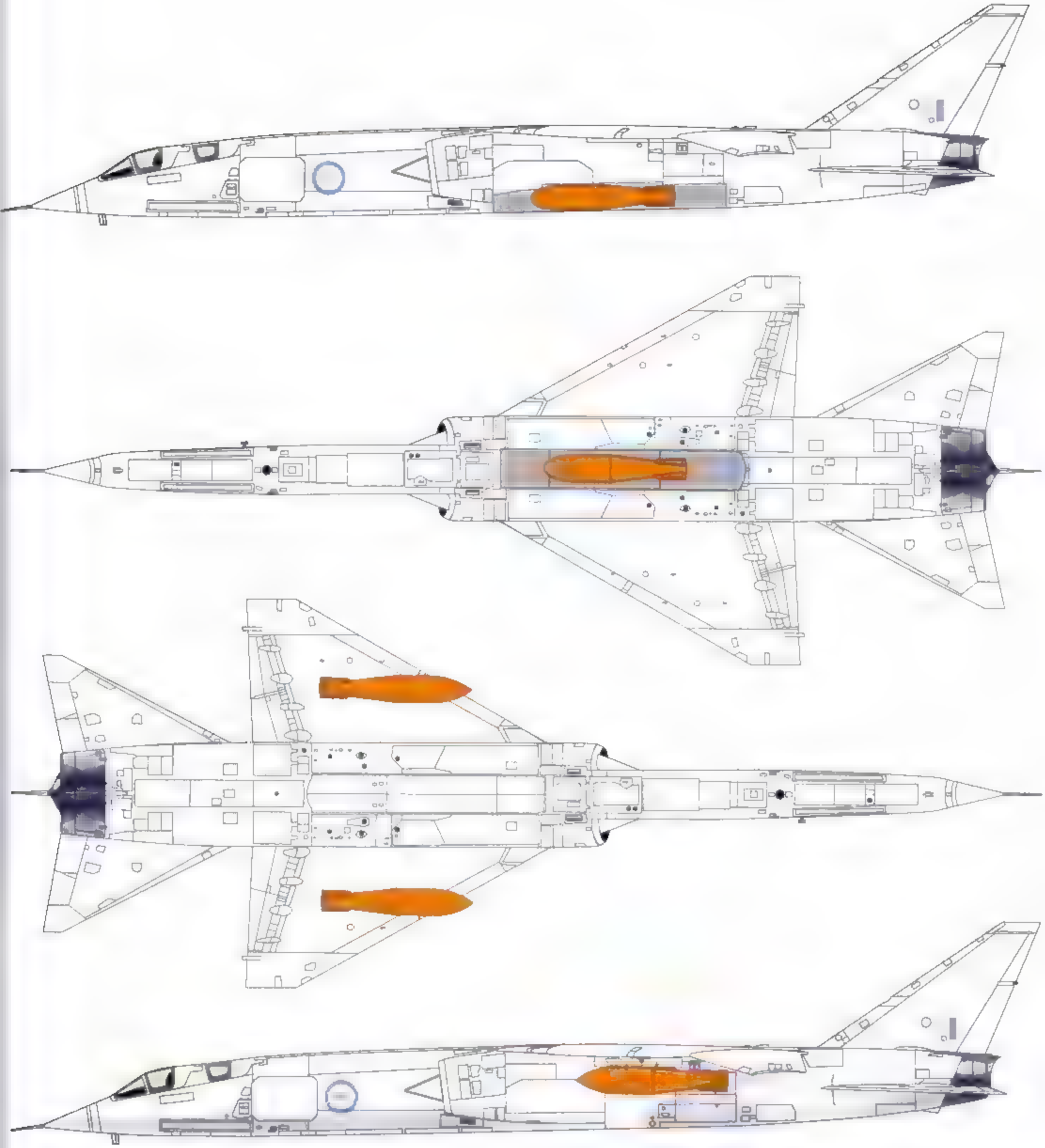
As originally designed, Red Beard had a blunt rounded nose which is thought to have been necessary to absorb the shock loads generated by a laydown delivery. Whilst this was of little consequence when the weapon was carried internally by types such as the Buccaneer and Canberra, if the weapon was to be carried externally by high speed aircraft such as the Sea Vixen and Scimitar some modification was necessary for aerodynamic reasons. The suggested modification to the nose resulted in a more pointed, aerodynamically streamlined shape which increased the length of the weapon by 12 inches from 12 to 13ft. Diameter remained unchanged at 28 inches.

There appear to have been a number of problems with the idea of using Red Beard on TSR.2. The first was related to the fact that Red Beard had been designed for internal carriage by subsonic aircraft and had not been designed to meet the vibration, stress or release conditions which would be imposed by TSR.2's operational environment. Whilst the 'quick fix' of modifying the nose to give a more streamlined shape would might allow its external carriage at subsonic speeds in an emergency, this speed limitation would inhibit the TSR.2's performance and this was considered unacceptable. The second problem was that the fusing system was not suitable for a shallow loft delivery, a third problem was that the design of the warhead did not cover the yields needed for the range of targets to be attacked and finally, it appeared likely that Red Beard would become obsolete during the timeframe allotted for TSR.2's development. This arose out of the perceived need to renew certain major components of Red Beard after some four or five years in service. Therefore the specification for a new tactical nuclear weapon which would be capable of being carried externally at supersonic speeds was raised in 1959 as Operational Requirement 177.

Thought to have been Gloss Black overall, Red Beards were repainted Dark Green so as to match conventional bombs and thus not stand out as a 'Special' weapon from a distance

WE 177

The weapon which eventually emerged to OR 177 became known as WE 177. Unfortunately, the files relating to the WE 177 weapon remain closed so comparatively little is known about its development. Initially at least, three warhead designs were under



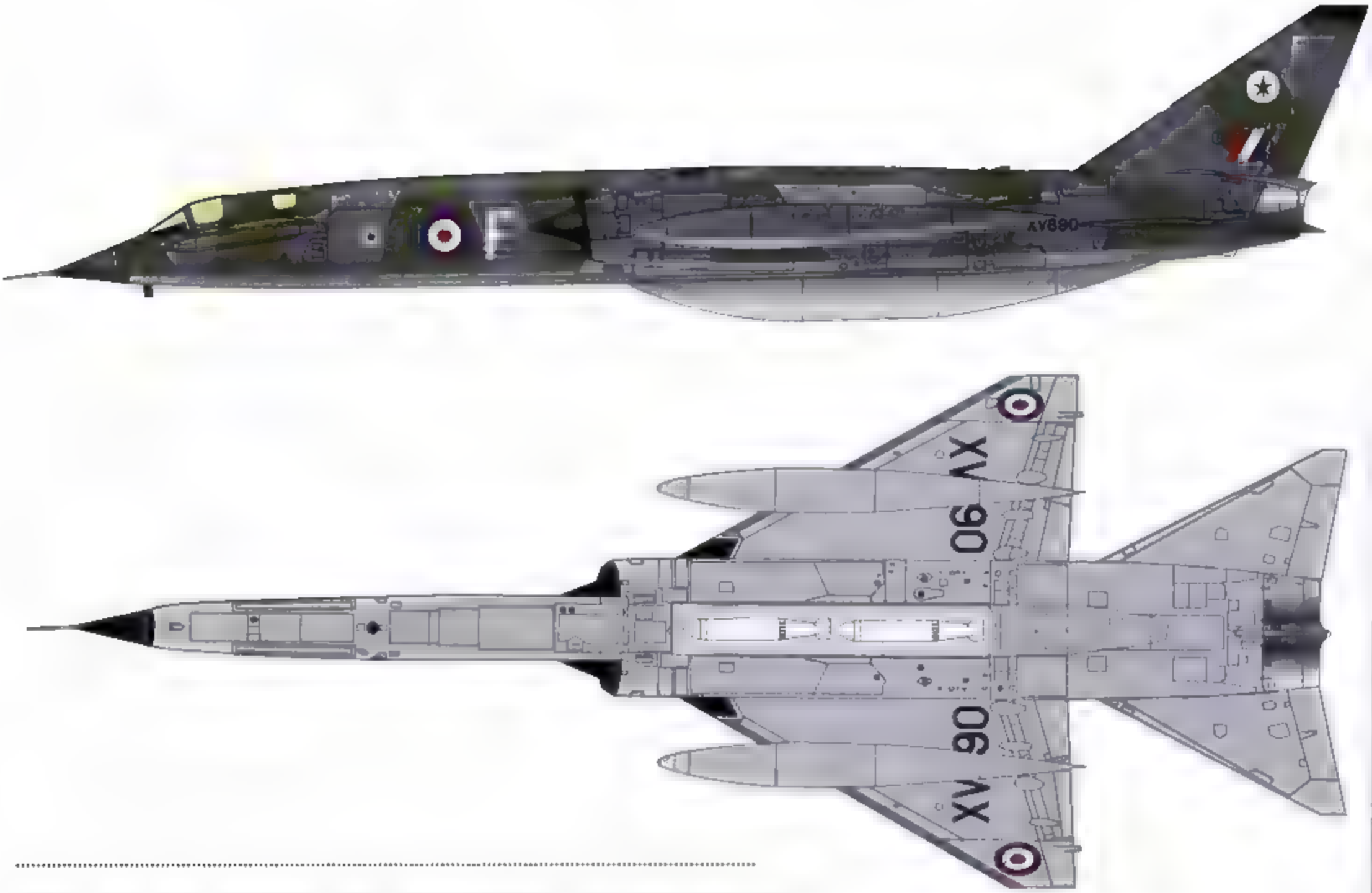
Red Beard

Two versions of the Red Beard are shown here. The first has the original blunt nose which was of no consequence aerodynamically when the store was carried internally on types such as the Buccaneer and Canberra and it was this version was used in the early design studies of TSR2. In this version Red Beard had an overall length of 12 ft. and a maximum diameter of 28 in. which tapered down to 9 in. at the tail. The fins spanned 28 in.

The second version is shown with the proposed modification to the nose which was intended to make Red Beard more suitable for external carriage on high speed aircraft such as the Sea Vixen and Scimitar. In this version the overall length was increased to 13 ft. with all other dimensions appearing to remain the same as those given above.

In the event, Red Beard was dropped from the TSR.2 programme on account of its general unsuitability on technical grounds and also its impending obsolescence within the TSR.2s development time frame.

The overall colour of the live operational Red Beard is thought to have originally been gloss Black, though later they are thought to have been finished in Dark Green BS 381C No. 641 as they were serviced.



Two WE 177As carried internally in tandem by XV890 coded 'F' of 81 Sqn as it might have appeared in 1972 under the provisions of Plan 'P' of March 1964

The nuclear weapon actually selected for TSR.2 was the WE 177. In its original form, the WE 177 was intended to be a purely tactical nuclear weapon and the carriage of two of these weapons internally was agreed during 1961. Initially, these weapons were perceived as being carried in tandem in the weapons bay as shown here but it was possible to carry the WE 177A externally under at the inboard stores station. The WE 177A was 9ft 4in long and had a diameter of 16.5in.

The WE 177As were basically White with an orange band approximately two inches wide and a yellow approximately one inch wide an inch apart running around the nose. The body of the bomb was also marked with a number of red warning triangles. From the early 1970's onwards the RAF toned down much of its equipment and it is thought that as the bombs were serviced, it is likely that they would have been refinished in Dark Green BS 381C 641 as they were capable of being carried externally.

Under the provisions of Plan 'P' it was intended to deploy a single TSR2 squadron of 10 aircraft UE to FEAF which was to carry out both Strike and Reconnaissance roles. The Reconnaissance squadron patterns which survive from the early to mid 1960's show that the identity of the TSR2 squadron in FEAF was expected to be 81 Sqn which in 1964 was equipped with Canberra PR.7s at Tengah.

XV890 was part of the F-111K serial number allocation which it is suggested would have been used for TSR2 where it would have been one of the thirty seven aircraft which BAC expected to produce during 1970. Finished in the standard high gloss polyurethane finish to the provisions of DCI S.136/69, XV890s squadron markings are based on the markings which were applied to the squadrons Canberra PR.7s. These consist of the squadrons Mullet and Dagger on a white disk with a pale blue outline on the fin and the 'Ace of Spades' playing card motif in black and white on the fuselage.

consideration. The first was an apparently British design called Red Snow which was at an advanced stage in development in August 1961, the second was the proposed Skybolt warhead and the third a somewhat more notional design similar to that embodied in the US Mk.43 weapon. It is claimed that the warhead eventually used was known as 'Cleo' and was the primary warhead developed for the RE.179 thermonuclear warhead which was intended for use in the British version of Skybolt. Whatever design of warhead was ultimately selected, it has been claimed that the prototype was detonated in an underground test code name 'PAMPAS' in Nevada on 1 March 1962.

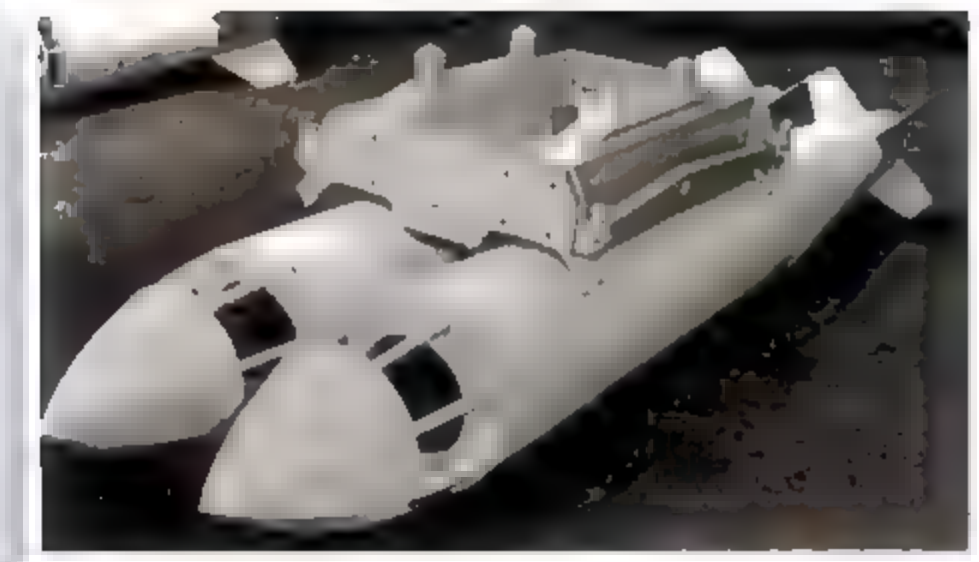
Physically, WE 177 was much smaller than Red Beard at 9ft 4 in long with a diameter of 16.5 inches and could be delivered either by lofting or laydown with a yield of 200 kilotons.

Work on WE 177 was sufficiently advanced by April 1961 that Amendment List 1 to OR 343 dated August 1961 stated that the internal carriage of two tactical nuclear weapons had been agreed. By December 1963 the number of WE 177s required for the TSR.2 force had been established as being 84 weapons of which 76 were intended for front line 'use' with 8 weapons held in reserve.

Along with the requirement for dual carriage of the WE 177A, there was also a requirement that these two weapons should be capable of being dropped in a stick, as being of a comparatively low kiloton yield it was thought necessary to employ stick bombing to compensate for the low yield in attacking some targets. The specification for the bomb appears to have had this method of delivery written into its specification, apparently calling for the assurance of a full yield detonation of all bombs dropped in a stick with a minimum spacing of 1,000 yards.

Ultimately, provision for twin carriage of the WE 177 by TSR.2 in a purely tactical role was overtaken by events with the scrapping of Skybolt in December 1962 as described above. A preliminary design study had been carried out by the RAE under the title 'A Survey of the Problems in Design of a Megaton Lay down Weapon for the TSR.2' which was published in January 1961 and it is thought that this study provided the basis for the developed WE 177 with a megaton yield which was put in hand in January 1963.

As far as TSR.2 in the tactical strike role is concerned, by December 1963 of the original 84 WE 177s required for TSR.2, 53 were now to be of the thermonuclear WE 177B type which would appear to have made the requirement for stick bombing with nuclear weapons unnecessary. However, it was thought that retention of the stick bombing capability would allow for maximum flexibility in the weapons system and be relatively simple to achieve.



A mock up of the side-by-side WE 177B installation for carriage in the forward part of TSR.2s weapons bay

The interior of the weapons bay doors were contoured so as to accommodate the side-by-side WE 177B installation

TSR.2 was to carry both WE177A and WE177B with the 'usual' load being two of one or other of these weapons in one of three possible ways, depending on the mission profile. The first option was to carry two WE177As in tandem in the weapons bay. The second option was to carry two WE177Bs side-by-side in the forward part of the weapons bay, thus leaving the rear part free for a fuel tank. The third option was to carry two of either type externally with one weapon at each of the inboard weapon stations.

WE 177 colours

Early production WE 177Bs are known to have been finished White all over with an orange band approximately two inches wide which denoted a nuclear store and a yellow band approximately one inch wide which signified a high explosive filling, separated by a gap approximately one inch wide around the nose. The sides of the bomb were also decorated with a number of explosive device warning triangles in red which are thought to have been related, in part at least, to the parachute installation in the tail of the bomb. Later weapons appear to have been Dark Green overall.

Project 'E'

Apart from the British designed weapons mentioned above, TSR.2 would also have been capable of carrying US designed nuclear weapons earmarked for the RAF under what is sometimes referred to as 'Project Emily' or more usually 'Project E'. Project E was the code name under which provision had been made for the supply of those RAF aircraft assigned to SACEUR with US built nuclear weapons in wartime which had its origins during Winston Churchill's second Premiership following his attendance at the 1953 Bermuda Conference.

Theoretical work which might one day lead to an Atomic Bomb had begun in Britain between the wars. When it became clear that this work might actually lead to a weapon it was assigned the code name 'Tube Alloys' and was transferred to the United States following the American entry into the war when it became apparent that Britain did not have the resources needed to bring the Atomic Bomb to fruition. British participation in what became known as the Manhattan Project continued until the end of the war, following the Quebec Agreement in which Churchill and President Roosevelt agreed to share equally the fruits of atomic research.

At the end of the war however, following a change of President as a result of Roosevelt's death, the US Senate which apparently did not know of the Quebec Agreement voted to implement the McMahon Act in 1946 which forbade the disclosure of nuclear information to any other state in an attempt to prevent nuclear proliferation.

That Britain was included in this ban infuriated some members of Clem Attlee's newly elected Labour government which had swept Churchill from office in 1945, most notably the Foreign Secretary Ernest Bevin who referring to the Atomic Bomb famously stated "We have got to have this thing over here whatever it costs and we have got to have a bloody Union Jack on top of it".

At Bevin's insistence, the Labour government of 1945-51 proceeded with a British Atomic Bomb project which was continued by Churchill's Conservative government from 1951 onwards. Whilst this had reached fruition by 1953 Britain's Atom Bomb project was some way off reaching its full potential.

The Bermuda Conference of 1953 was Churchill's idea as he hoped to gain President Eisenhower's support for a top level dialogue with the new Soviet leadership following the death of Stalin. Churchill also hoped to discuss 'collusion on atomics' with the Americans.

Prior to the conference the Ministry of Supply made a case for approaching the US by stating that the RAF was in the process of equipping with modern Jet Bombers (Valiants, Vulcans and Victors) but that their full value would not be obtained unless they could be equipped with atomic bombs. The same applied to the tactical bomber squadrons whose re-equipment with Canberras was now far advanced. Britain was only just beginning production of atomic bombs, the first of which was delivered to the RAF in November 1953. It was thought that Britain would not be able to manufacture more than 100 such weapons by the end of 1957 rising to about 350 by the end of 1960.

It was thought that the US had by this time accumulated a stockpile of about 2,500 atomic bombs of various types and that

The recess seen here was intended to accommodate the tail fins of the WE 177B

A pair of WE 177Bs on display at RAFM Cosford. Originally, these weapons were gloss White overall eventually being repainted Dark Green as seen here

Two WE 177Bs carried side by side internally by XS953 coded 'D' of 12 Sqn as it might have appeared in 1969 in the 'Spotswood scenario' carrying a full load of drop tanks

The WE 177B was developed as a direct result of the need to produce a stop-gap deterrent in the wake of Skybolts cancellation in December 1962. Initially intended to be carried by the V-Bombers, it was realised that this weapon would also bestow a strategic nuclear capability on TSR.2 and by December 1963 of the 84 WE177s on order for the TSR.2 force, 53 were to be of the more powerful thermonuclear WE 177B type. Because of its greater length which was necessary to accommodate the two stage thermonuclear warhead, it was no longer possible to carry the bombs in tandem and a side by side arrangement in the forward part of the weapons bay was adopted instead. This left the rear of the weapons bay free for a non jettisonable fuel tank which helped increase TSR.2s range in the strategic role. The WE 177B was 11ft 1in long and had a diameter of 16.5in.

XS953 was one of the batch of ten TSR2s BAC expected to be able to produce during 1968 and is therefore camouflaged and marked in accordance with the TSR Scheme as laid down in DCI S.126/66. This called for TSR aircraft to be finished in gloss polyurethane Dark Green BS 381C 641 and Dark Sea Grey BS 381C 638 on their upper surfaces with the under surfaces finished in Light Aircraft Grey BS 381C 627. National markings were to be applied using Post Office Red BS 381C 538, White and Roundel Blue BS 381C 110 and serial numbers were to be Black.

It is suggested that XS953 might have been one of the six production aircraft allocated to 40 Squadron upon its move from Coningsby to Honington where it would adopt the number plate of 12 Squadron (Motto 'Leads the Field') and become the first fully operational TSR2 squadron.

The squadron markings are based on known practice by 12 Sqn and consist of the well known Fox's face upon the fin with the squadron number applied above in Roman numerals as was applied to the intakes of the Squadrons real world Buccaneers whilst the Black, White and Green squadron colours which flank the squadron badge in its standard frame upon the fuselage are those which are currently displayed upon the Tornado.

The individual aircraft letter has been shown as being Yellow as a hold over from the previous 40 Sqn Scheme.

The basic colour of the weapons bay interior is a very pale grey whilst the WE 177Bs were basically White with an orange band approximately two inches wide and a yellow approximately one inch wide an inch apart running around the nose. The body of the bomb was also marked with a number of red warning triangles. From the early 1970's onwards the RAF toned down much of its equipment and it is thought that as the bombs were serviced, it is likely that they would have been refinished in Dark Green BS 381C 641 as they were capable of being carried externally. The fuel tank might have been the same pale grey colour as the rest of the weapons bay, Anti-Flash White or as shown here for maximum artistic effect, Indian red. Indian red was the traditional colour for internal fuel tanks and was a product of the red iron oxide pigment used in the specification for fuel proof paint which was applied as an anti corrosion measure.

production was running at about 600 a year.

Under these circumstances it did not seem unreasonable to ask the US to help Britain with a modest supply of atomic weapons pending the creation of an adequate stockpile of British manufacture. This was seen as being to the American's advantage since it would enable the RAF to play their full part with Strategic Air Command in the counter bombardment of targets in the Soviet Union and would greatly increase the effectiveness of the support which the British Tactical Air Forces could give Allied armies on the Continent.

It was realised that the Americans would probably not be willing to hand over the weapons until hostilities were imminent. however other than the possibility of war breaking out without any warning, this would not matter greatly since the allocated weapons could be kept in American stores and transported to RAF airfields at very short notice.

What was important was that the necessary technical information to enable the RAF to use US weapons in the event of their being supplied should be obtained as soon as possible. The principle points on which information was required were the weights, dimensions and fusing arrangements of the US weapons and the methods of attaching them to and releasing them from the aircraft.

Churchill therefore raised the matter with President Eisenhower and on 5 December 1953 Eisenhower stated that he did not think that there would be any serious objection to the US supplying Britain with the required details of the external characteristics of their bombs so that RAF aircraft could be modified to carry them. Following an amendment to the US Atomic Energy Act in 1954 it would appear that work to allow this began the same year under the designation 'Project 'E'.

After Britain successfully exploded its first H-Bomb in 1957 President Eisenhower proposed amendments to the 1954 Atomic Energy Act to permit greater exchange of nuclear technology with those countries which had made substantial progress in the development of nuclear weapons, which in effect only meant Britain. The successful launch of Sputnik by the Soviet Union in the summer of 1957 led to further concessions to Britain which led to the 1958 Atomic Energy Act which put no limit on the nuclear technology imparted to Britain.

By the Autumn of 1958 the Director of Operations (Bombing and Reconnaissance) at the Air Ministry had been charged with contacting the Headquarters of the US 3rd Air Force with a view to concluding a working agreement of Project E for the Canberra forces of 2 TAF and Bomber Command.

As a result of negotiations with HQ 3rd Air Force a form of agreement was prepared which was acceptable both to 3rd Air Force and to the Air Ministry by mid November 1958. Whilst the final form of the agreement appears to remain classified, a draft copy is now in the public domain which sheds a great deal of light on how the arrangement worked.

The agreement was referred to throughout the document as an 'arrangement' at the request of the Americans in what appears to be an act of political semantics. It would appear that if the Project E agreement was actually referred to as an agreement, it would have to be registered as such with the other partners in NATO, and if this was done, then the secret that the RAF was equipped to carry US nuclear weapons would be exposed.

The arrangement related to the provision of US nuclear weapons for delivery by the Canberra Light Bomber Force in the event of a general war. It was agreed by both the RAF and USAF that the agreement set out the mutual understanding of the responsibilities of both Services for the implementation of Project E – Canberra Force.

Provision of weapons

SACEUR would assign nuclear weapons to the Canberra Light Bomber Force from his allocation and indicate the numbers to be assumed for planning purposes.

By this time the number of Canberra aircraft to be modified and provided with the necessary equipment to carry US Mk.7 weapons were given as 48 Canberra B.6s in Bomber Command along with 12 Canberra B(I).6s and 36 Canberra B(I).8s of 2 TAF in RAF Germany.

It was stated that the entire front line Unit Establishment of B.6s and B(I).6s were already modified together with 30 B(I).8s. The build up to 36 modified B(I).8s was expected to be complete by the end of December 1958. What is described as 'carrier and control equipment and bomb hoisting gear' was stated to be available for these aircraft whilst adequate quantities of training and test equipment were expected to be available by the end of December 1958. The cost of the modification and reequipment of these aircraft was to be borne by the UK.

It is interesting to note that the equipment of the aircraft with LABS is not mentioned in this document and it would appear that the addition of this equipment to the Canberra was considered to be in addition to their modification to carry the US Mk.7 bombs.

Airfield Programme

In November 1958 a decision had yet to be reached as to whether Bomber Command's Project E Canberras would be based at Binbrook or Coningsby and therefore the target date for the completion of the technical facilities had yet to be set. Ultimately, Coningsby was chosen. Whether this played any part in the decision to locate the first operational TSR.2 squadrons on this station is not currently known. In RAF Germany the 2 TAF Canberras were to be deployed at Geilenkirchen, Wildenrath, Bruggen and Laarbruch. The target date for completion of the technical facilities at these airfields was 1 July 1959.

Custody and release of weapons

Prior to release by SACEUR, the USAF was to retain physical possession and authority over US atomic weapons. To this end the USAF was to provide necessary personnel and equipment to allow them to perform all functions incident to storage, maintenance, modification, operational readiness and internal security of US atomic weapons on operational RAF Stations to the extent required by extant US law. The USAF was to ensure that whilst in storage and up to transfer to the RAF weapons would be maintained in a completely safe configuration meaning that at no time would there be the possibility of an accidental nuclear explosion.

Physical facilities, normal base support, loading capability and operational delivery was to be the responsibility of the RAF. The US atomic weapon would be married to the RAF delivery aircraft.

Command and Control

SACEUR was to be responsible for authorising the release of the weapons to the RAF, co-ordination of actual combat operations by the Canberra Light Bomber Force and planning detail on the scale of effort demanded of the RAF Light Bomber Strike force for which the USAF weapons might be assigned.

The USAF was to be responsible for delivery of complete nuclear weapons after release by SACEUR to the transfer control point which was to be established at the entrance to the special weapon storage area, for the transfer of the prescribed weapons to the RAF Strike force commander or his designated representative and for the provision of technical monitors to advise RAF Strike Force commanders and loading crews on any technical problems which might arise during the loading of the weapons.

The RAF was to be responsible for receipt of the weapons at the control point referred to above, transfer of the weapons to the RAF aircraft, loading of the weapons onto these aircraft and finally the delivery of the weapons to their target.

XV930 coded 'G' of 617 Sqn as it might have appeared in 1972 in the 'Spotswood scenario' armed with two US Mk. 43 Bombs provided under Project E carried externally under the wings and also carrying a 1,435 gallon ventral drop tank

XV930 might have been built as part of the last batch of 28 aircraft to have been built during 1971 under the final plan for production put forward by BAC on 10 March 1965. This serial number was actually allocated to one of the forty-six F-111K aircraft ordered following TSR2's cancellation but it is suggested that had TSR2 entered production then this serial number would have been allocated to TSR2 production instead.

XV930 is shown in the TSR Scheme as laid down in DCI S. DCI S.136/69 dated 13 August 1969 which stated that TSR aircraft which were to be finished in Dark Green BS 381C 641 and Dark Sea Grey BS 381C 638 on their upper surfaces with the under surfaces finished in Light Aircraft Grey BS 381C 627. National markings were to be Post Office Red BS 381C 538 White and Roundel Blue BS 381C 110 and serial numbers were to be Black.

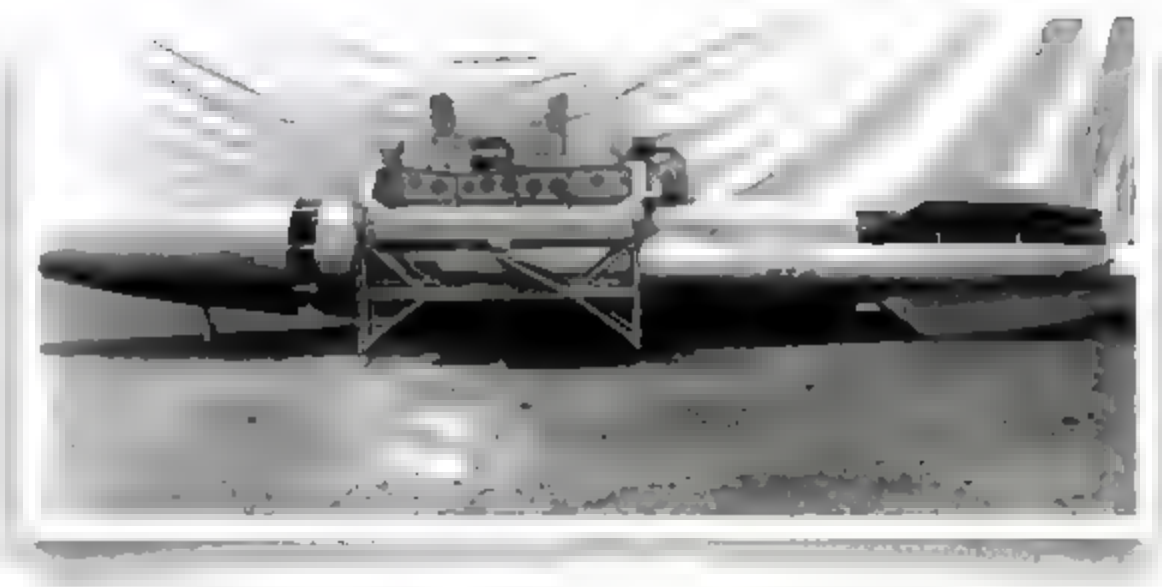
XV930's squadron markings are based on known practice by 617 Sqn. The fin marking is based upon that carried by the Squadrons Vulcan B.2s during the early 1970s whilst the colours flanking the squadron badge inside its standard frame on the fuselage are those used on Tornados.

The US Mk. 43 Bombs were provided for RAF use under Project E but with a length of approximately 14ft 6in and a diameter of 18 in were two large for two to be carried internally. In order that the same degree of target coverage could be maintained, it was therefore necessary to carry the two weapons externally under the inboard stores stations.

Unfortunately the exact size and shape of the pylons is not known, it is however known that they were built for the purpose and were not the standard pylons used to carry conventional bombs and rocket pods. The pylons shown here are based on the design of the pylons intended to carry the US Mk. 28 nuclear weapon before this proposal was dropped.

As far as the TSR.2 is concerned, it would appear that initially it was expected that the type of US weapon which would be supplied under Project E would be either the Mk.7 as used by the Canberra or alternatively the 1,900lb Mk.28.

The US Mk.28 had entered production in January 1958 and was subsequently developed through a number of different variants which could be delivered in a variety of ways from freefall to laydown with differing yields in both the kiloton and megaton ranges. Other than the weight specified in the TSR.2 design studies, there is little reliable information on exactly which variant of this weapon the TSR.2 was expected to carry. The Mk.28 was 22 inches in diameter and could be between 96 and 170 inches (8–14ft) in length, depending upon the sub-type, and it is apparent that the 1,900lb version which would be supplied to the RAF was too large to accommodate two weapons internally in TSR.2's weapons bay. Therefore provision had to be made to carry these weapons externally and wind tunnel trials were carried out with the bombs hung under specially shaped pylons in the inboard under wing position.



A mock up of the US Mk.43 bomb seen fitted with a carrier. The US Mk. 43 was too big for TSR.2 to carry two internally. This weapon would therefore have had to be carried externally

Mk.43

By August 1963 the US Department of Defence was planning to withdraw the Mk.7 from service altogether but a debate emerged as to whether TSR.2 would be able to carry its replacement the Mk.43 which was to be utilised by the Valiants and Canberras assigned to SACEUR. The US Mk.43 was basically a laydown bomb for high-speed low-level delivery of which 1,000 were manufactured between April 1961 and October 1965. In RAF terminology this weapon was known as the 2,100lb HC No.2 and like the Mk.28 it was too big to allow internal double carriage inside TSR.2's weapons bay. Therefore, like the Mk.28, provision was made to carry the weapon externally under the wings in the inboard pylon location.

The debate turned on three issues, whether it was technically feasible for TSR.2 to carry US weapons, whether it would be politically acceptable for them to do so, and whether it would be practical operationally for them to do so.

The technical debate centred around the question as to whether TSR.2 would have to be rewired to US requirements in order to be able to utilise the Mk.43s. As built, the TSR.2 was wired for the carriage of nuclear weapons in the same way as the Valiants were wired to allow them to carry the Mk.43. However, this wiring was only available under a special concession and might not be suitable for TSR.2. If the matter could not be sorted out quickly, the result might be that a number of TSR.2s would leave the production line unable to carry one of the main weapons which it was intended that they should deliver and that rewiring TSR.2s would prove to be very expensive. Ultimately, it would appear that the wiring as installed was fit for purpose and carriage of the Mk.43 would have been possible without altering the wiring specification.

The political problem centred not so much around whether the Americans would be willing to supply Britain with their cutting edge technology, but at what level the matter could be sorted out. The Ministry of Defence was reluctant to involve either the Foreign Office or US State Department in a diplomatic approach, much preferring to try to sort the matter out for themselves by dealing directly with the US Department of Defence if at all possible. As far as the US Department of Defence was concerned, there would be no difficulty in providing the RAF with the Mk.43 for TSR.2 and it would appear that the matter was eventually sorted out to the RAF's satisfaction.

That just left the operational problem with the idea of utilising Project E weapons in conjunction with TSR.2. The operational doctrine of the RAF dictated that its bomber force disperse from its usual operational bases in times of international tension. Under these plans it was assumed that the TSR.2 force would disperse to a number of predetermined and prepared sites, which unlike those selected for the V-Bomber force would not necessarily be proper airfields, thus utilising the TSR.2's short and rough strip performance. As the US weapons were held under the 'dual key' arrangement, the dispersal of the force, possibly all over Europe, was seen as the likely cause of command and control problems which might render the force ineffective.

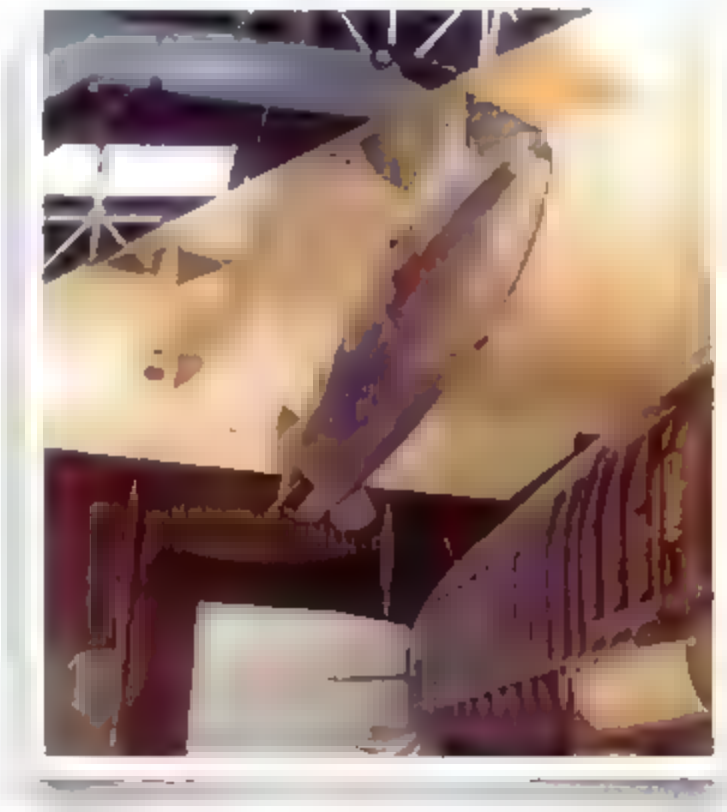
This problem would not occur if the aircraft were armed with British weapons as these would be entirely under British control.

Delivering the weapons

There were two methods which could be employed by tactical aircraft to deliver freefalling nuclear bombs such as those described above, using the Low Altitude Bombing System (LABS) or by laydown.

Low Altitude Bombing System (LABS)

Colloquially known as 'lofting' the LABS involved calculations being made of how far a bomb of known ballistic properties could be 'tossed' forward when released from an aircraft at a given speed and angle. The delivery aircraft then approached the target at low level and high speed until it was at the previously determined distance. The aircraft was then put into a climb at a particu-



A mock up of a US Mk.43 bomb on an inboard weapons pylon

XS668 coded 'L' of 9 Sqn as it might have appeared in 1972 in the 'Spotswood scenario' armed with two WE 177Bs carried internally and a full load of external drop tanks

XS668 was to have been one of the eleven pre production TSR2s which would probably have been initially issued to the ODS before being passed on to 237 OCU. As deliveries of full production TSR2s gathered pace it was planned that six of the pre production batch would be returned to the manufacturers for modification to full production standard and it is suggested that XS668 would have been one of these aircraft.

As part of the modification to full production standard it is suggested that XS668 would have been completely repainted from the half White BAC works scheme illustrated in Chapter 4 into the TSR Scheme as outlined in DCI S.136/69 which called for Dark Green BS 381C 641 and Dark Sea Grey BS 381C 638 on the upper surfaces with the under surfaces finished in Light Aircraft Grey BS 381C 627. Due to a change in policy, from March 1971 the gloss polyurethane finish was replaced by a matt polyurethane finish and White was eliminated from the national markings on camouflaged aircraft so that roundels and fin flashes consisted of Post Office Red BS 381C 538 and Roundel Blue BS 381C 110 only.

Due to the way in which the relevant instructions were written there appears to have been some misunderstanding with regard to the under wing roundels which remained Red, White and Blue on many aircraft for some time.

lar airspeed, angle and 'g' loading with the bomb being released and 'tossed' forward along the flight path towards the target whilst the aircraft completed a half loop, rolling of the top before presumably diving back down to low level to make its escape.

A variation on this technique was the 'over the shoulder' delivery which did not involve the delivery aircraft flying directly towards the target on the run in. Instead, the aircraft was turned onto a heading towards the target with a roll manoeuvre during the first half of a loop with the bomb being released when the aircraft was at an angle of 110 degrees to the horizontal. Whilst the aircraft completed the roll and loop making good its escape in the process, the bomb had effectively been thrown 'over the shoulder' of the departing aircraft and continued towards the target.

The drawback to this method of delivery was that as the strike aircraft entered into the LABS manoeuvre it gained altitude which rendered it vulnerable to ground defences. What was really needed was a means by which a nuclear weapon could be delivered without the aircraft having to climb to such an altitude that

Because of its size, the US Mk.43 would have to have been carried on the inboard underwing stores station

Laydown delivery

The method of laydown delivery was devised to enable an aircraft to drop a large yield nuclear weapon without having to climb up from the comparative safety of low altitude. The bomb was retarded, usually by parachute, immediately after release to such a velocity in impact with the ground that various shock attenuation devices on board the bomb restricted the impact shock to the weapon sufficiently to leave the weapon serviceable. Detonation then occurred after a suitable delay in order to allow the aircraft to escape. With TSR.2 escaping at 0.9M at low level under overcast weather conditions a minimum escape time of 25 seconds was calculated assuming that the bomb would travel 1,000ft forward along the flight path after release before coming to rest, a 2 second tolerance on fuse timing and that the TSR.2 airframe could withstand a thermal pulse of 55 cal per square centimetre.

The Strike Squadron Patterns

Squadron Patterns was the term used by the Air Ministry to describe which squadrons would equip with which type in what part of the world. Unfortunately, very little remains of the proposed squadron patterns for the TSR.2. By 10 November 1964 it was being assumed for planning purposes that the introduction of TSR.2 to service had slipped by 9 months and that the first full production aircraft would not be delivered until January 1968. In the event, the production schedule put forward by BAC in March 1965 suggests that this would not have taken place until April 1968. It was therefore decided that full squadron patterns would not be devised until firm delivery dates including a realistic build-up of aircraft had been negotiated with the Ministry of Aviation. It would appear that such information had not been received prior to TSR.2's cancellation in April 1965.

It is however possible to speculate as to which squadrons might have been equipped with TSR.2 by applying known MoD policy to a document entitled "Proposed Plan For Operational Squadron Number Plates Over The Next Three Years" dated 23 October 1968.

Following the Duncan Sandys 1957 Defence White Paper, the Air Staff formulated the policy of aiming to preserve the number plates of all squadrons awarded a Standard with due reference to seniority of service with some weight being given to service in a particular command, Theatre and role. This was the thinking which saw Bloodhound SAM squadrons adopt the number plates of Fighter squadrons and Thor IRBM squadrons the number plates of Bomber squadrons.

The proposed plan of 1968 listed a total of 171 RAF Squadrons in order of seniority noting which squadrons had been awarded standards, their present equipment and command, their planned deployment to 1971 and their proposed future. From this list it is possible to suggest the squadrons most likely to have been considered for equipment with TSR.2 from 1968 onwards.

The original Plan 'P' called for two Strike squadrons and one Reconnaissance squadron in the UK, two Strike and two Reconnaissance squadrons in Germany, two Strike squadrons and one Reconnaissance squadron in NEAF and ■ mixed Strike and Reconnaissance Squadron in FEAF. This gives a total of six Strike squadrons, four Reconnaissance squadrons and one mixed squadron. From documents dealing with planning for the Reconnaissance squadrons it is possible to state that the mixed Strike and Reconnaissance Squadron which was to be equipped with 10 TSR.2s and stationed in the Far East as called for in Plan 'P' was expected to be 81 Sqn, but no documents have come to light which throw any light on the possible identities of the six Strike squadrons.

The Spotswood Scenario

As discussed in Chapter 1 however, Plan 'P' was modified by the Spotswood Report which concluded that the TSR.2 force required was 63 aircraft based in the UK assigned to SACEUR; 20 aircraft in NEAF and declared to CENTO though the individual squadrons would deploy on a rotational basis from the UK; 20 aircraft in FEAF also deployed on a rotational basis from the UK, and a UK, based strategic reserve of 20 aircraft of which 8 would be earmarked for NATO thus giving a front line total of 123 aircraft.

If this force of 123 aircraft is split up into squadrons using a standard UE of 12 aircraft per Strike squadron and ■ aircraft per Reconnaissance Squadron, then the UK based force assigned to SACEUR of 63 aircraft would essentially make up 4 Strike Squadrons of 12 aircraft plus two Reconnaissance squadrons of 8 aircraft (which actually gives a total of 64 aircraft). The 20 aircraft in NEAF, FEAF and the UK based strategic reserve would consist of 1 Strike squadron with 12 aircraft and 1 Reconnaissance squadron with 8 aircraft. This gives a total of 7 Strike Squadrons and 5 Reconnaissance Squadrons.

If the Air Board policy is applied to the proposals in the Spotswood Report using the information contained in the Proposed Plan For Operational Squadron Number Plates Over The Next Three Years dated 23 October 1968, the following squadrons in order of seniority were serving as Strike Squadrons at the time and were proposed to continue in that role beyond 1971. It is therefore suggested that the following squadrons are likely candi-

dates to have received TSR.2 and to have operated them in the Strike role.

No. 6 Squadron
6 Sqn is the RAF's third most senior squadron and in 1968 it was equipped with Canberra B.16s in NEAF. It was planned to disband the squadron in 1969 and reform it within Air Support Command as a Phantom Strike squadron and this is exactly what happened. The Canberra squadron disbanded on 13 January 1969 and reformed as a Phantom squadron on 7 May 1969.

No. 14 Squadron
14 Sqn is fifth in seniority and in 1968 was part of RAF Germany where it was equipped with Canberra B(I).8s. It was planned to disband the squadron during 1970 and to reform it as a Phantom Strike squadron in Germany. This actually happened in June 1970.

No. 12 Squadron
12 Sqn is the tenth most senior RAF squadron and in 1968 the number plate was vacant as the squadron had disbanded in December 1967. In October 1968 it had already been earmarked as the first Strike Command Buccaneer squadron and as this was the type which the RAF actually ended up with following the cancellation of TSR.2 and F-111, 12 Sqn would appear to have been a strong contender as a TSR.2 squadron, if not the first fully operational TSR.2 squadron, to be formed by renumbering 40 Sqn which was discussed in Chapter 4.

No. 3 Squadron
3 Sqn is the RAF's twelfth most senior squadron which was then equipped with Canberra B(I).8s in RAF Germany. It was proposed that the squadron would disband in 1970 before reforming as an RAFG Phantom squadron. What actually happened was that the squadron retained its Canberras until January 1972 when it became a Harrier squadron.

No. 45 Squadron
45 Sqn ranks nineteenth in seniority and in 1968 was equipped with Canberra B.15s in FEAF. It was planned to disband the squadron in 1970 as part of the British withdrawal from east of Suez and it was proposed as a possible Strike Command Buccaneer squadron. In fact, the squadron was disbanded in January 1970 and did not reform until August 1972 when it received Hunter FGA.9s in Air Support Command.

No.9 Squadron
9 Squadron is the RAF's twenty-third most senior squadron and was equipped with Vulcan B.2s as part of Strike Command. In 1968 it was planned that 9 Sqn would continue to operate the Vulcan and deploy to NEAF during 1969 which is exactly what happened. 9 Sqn subsequently went on to become the first Tornado squadron in 1982.

No.32 Squadron
32 Sqn is twenty-fifth in seniority and was equipped with Canberra B.15s in NEAF. It was planned to disband the squadron in 1969 and was considered to be a possible Strike Command Phantom squadron. In the event, the squadron disbanded on 3 February 1969 and the number plate passed to the Metropolitan Communications Squadron at Northolt equipped with Bassets.

These squadrons are the seven most senior RAF Strike squadrons. As can be seen from this list, with the exceptions of 12 Sqn which was a vacant number plate and 9 Sqn which was equipped with Vulcans, all the other squadrons were equipped with Canberras, the type that TSR.2 was intended to replace. Another interesting point is that all the squadrons listed here except 9 Sqn were proposed as either Phantom or Buccaneer squadrons, the two types which ended up plugging part of the gap left by TSR.2's cancellation.

The special case of 617 Squadron

As can be seen from this list, in theory at least, the seventh most senior Strike squadron would appear to be No.32 Squadron. However, in a world where the Vulcan would have been phased out between 1970 and 1972 , it is possible that the RAF's arguably best known squadron, 617 Sqn, though more junior than any of the squadrons listed above, might have been kept in existence and equipped with TSR.2 in preference to a more senior squadron.

Evidence for this is to be found in surviving documents from 1968 which relate to the rundown of the Vulcan force as it actually happened. On 1 August 1968 the MoD wrote to HQ Strike Command to inform them that the squadron number plate situation had been under review and that the MoD wished to know which two Vulcan squadrons Strike Command wished to disband. The MoD noted that 617 was the most junior but that in view of its history it should almost certainly be retained (emphasis added). In a letter dealing with this matter dated 20 August 1968, HQ Strike Command agreed that 617 Sqn should be retained as a long term Vulcan Squadron along with 44, 50 and 101 Sqns whilst proposing that 27 and 83 Sqns be disbanded as the UK based Vulcan force reduced in size.

By November 1968 the Air Force Board had agreed two exceptions to their policy with regard to squadron seniority, 120 Sqn (ninety-eighth in seniority) and 617 Sqn (one hundred and twenty-seventh in seniority), both of which were considered to be unique as they had been awarded their Standards not as a result of length of service, but as a result of their outstanding Second World War record. In the event, 120 Squadron equipped with Nimrods whilst 617 Sqn retained its Vulcans, going on to become a Tornado squadron. Both 617 Sqn and 120 Sqn (albeit pooling their Nimrods with 42(R) and 201 Sqns) remain front line squadrons in the much smaller RAF of 2008 where more senior squadrons have been reduced to reserve status or have no place at all.

It has to be stressed that at the time of writing, no squadron patterns for the TSR.2 in the strike role are known to exist. The squadron number plates given above are speculative, as of course are the illustrations of TSR.2s carrying the markings of these squadrons.

Tactical Nuclear Strike proposals

Other than the Red Beard, WE 177A, WE 177B and Mk.43 weapons described above there were three weapons systems which were proposed as being suitable for use by TSR.2 in the Tactical Nuclear Strike role. These were the Barnes Wallis Momentum Bomb, the Avro W.130 and the Bristol Aircraft Ltd Tychon.

The Barnes Wallis Momentum Bomb

During 1957 Dr Barnes Wallis, chief designer at Vickers, made a typically ingenious suggestion as to how a low-flying aircraft might attack a target whilst remaining at low altitude without necessarily flying right over it as was necessary with a laydown attack, when he produced a memo entitled 'Momentum Bombing'.

The memo began by stating that every method of bombing when used against a target situated in enemy territory presented three major problems:

1) Location of the target
2) Identification of the target
3) Accurate delivery of the bomb while retaining an acceptable degree of immunity from attack for the bomber aircraft.

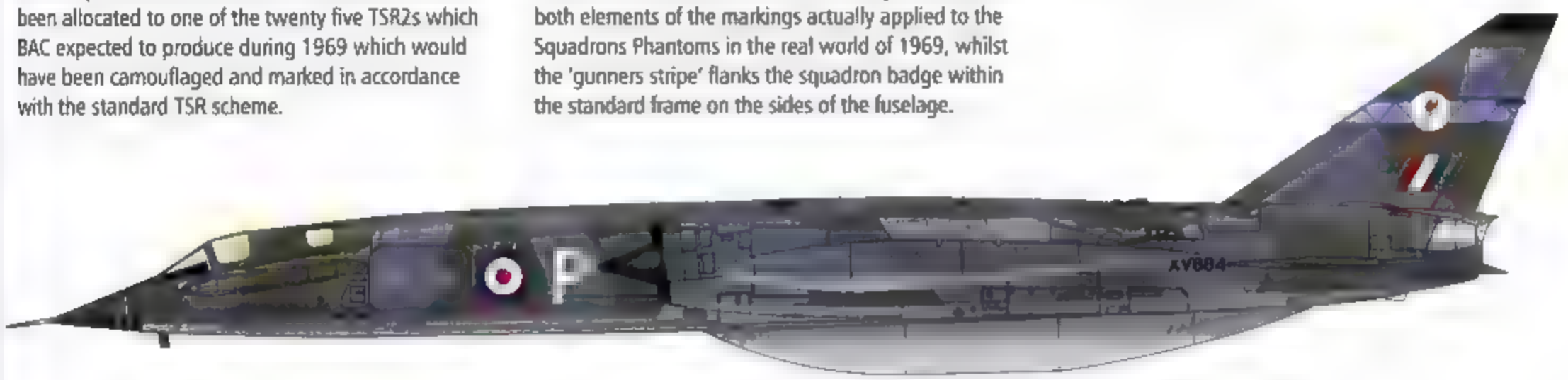
The location of the target was a navigational problem which was unaffected by the solution adopted for the delivery of the

XV884 coded 'P' of 6 Sqn as it might have appeared in 1970 in the 'Spotswood scenario' armed with two WE 177Bs carried internally and carrying a full load of drop tanks

XV884 was one of the serial numbers actually allocated to one of the forty-six F-111K aircraft ordered following TSR2's cancellation but it is suggested that had TSR2 entered production then this serial number would have been allocated to one of the twenty five TSR2s which BAC expected to produce during 1969 which would have been camouflaged and marked in accordance with the standard TSR scheme.

6 Sqns markings are shown as consisting of the traditional 'flying can opener' motif on a White disk flanked by the well known 'gunners stripe' extending across the full chord of the fin. This design incorporates both elements of the markings actually applied to the Squadrons Phantoms in the real world of 1969, whilst the 'gunners stripe' flanks the squadron badge within the standard frame on the sides of the fuselage.

The individual aircraft letter 'P' is shown in White as this was the colour used for these markings on the Squadrons Phantoms.

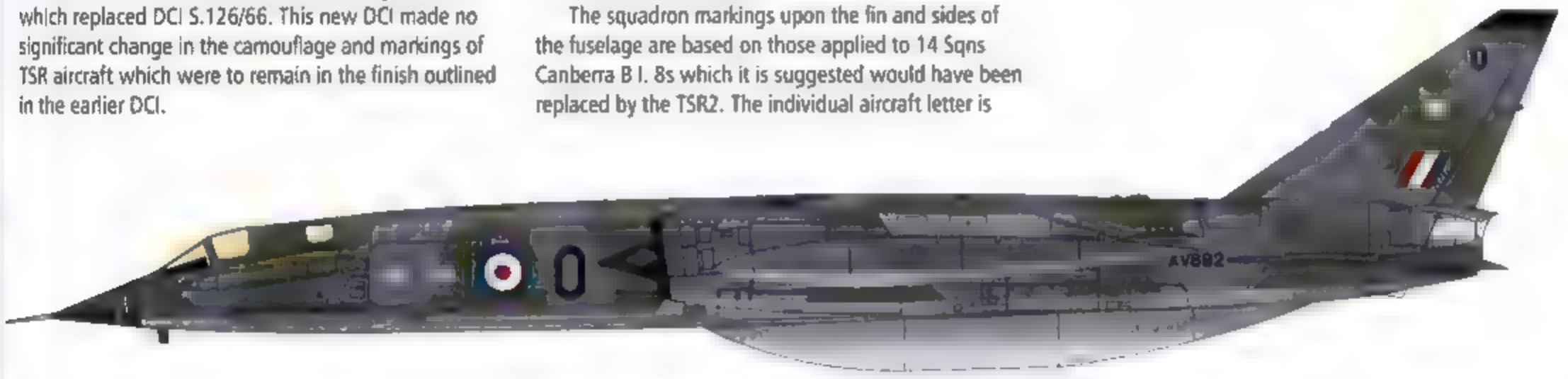


XV892 coded 'O' of 14 Sqn as it might have appeared in 1970 in the 'Spotswood scenario' armed with two WE 177Bs carried internally and carrying two under wing drop tanks

XV892 is another serial number which was actually allocated to an F-111K but which might be applicable to a TSR2. XV982 is shown in the TSR Scheme as laid down in DCI S. DCI S.136/69 dated 13 August 1969 which replaced DCI S.126/66. This new DCI made no significant change in the camouflage and markings of TSR aircraft which were to remain in the finish outlined in the earlier DCI.

XV982 has been illustrated without the ventral drop tank and with its weapons bay doors open in the under surface plan view to illustrate the twin WE 177B and fuel tank installation.

The squadron markings upon the fin and sides of the fuselage are based on those applied to 14 Sqns Canberra B I. 8s which it is suggested would have been replaced by the TSR2. The individual aircraft letter is shown in Black because this is the colour used for this purpose on the squadrons Canberra's.

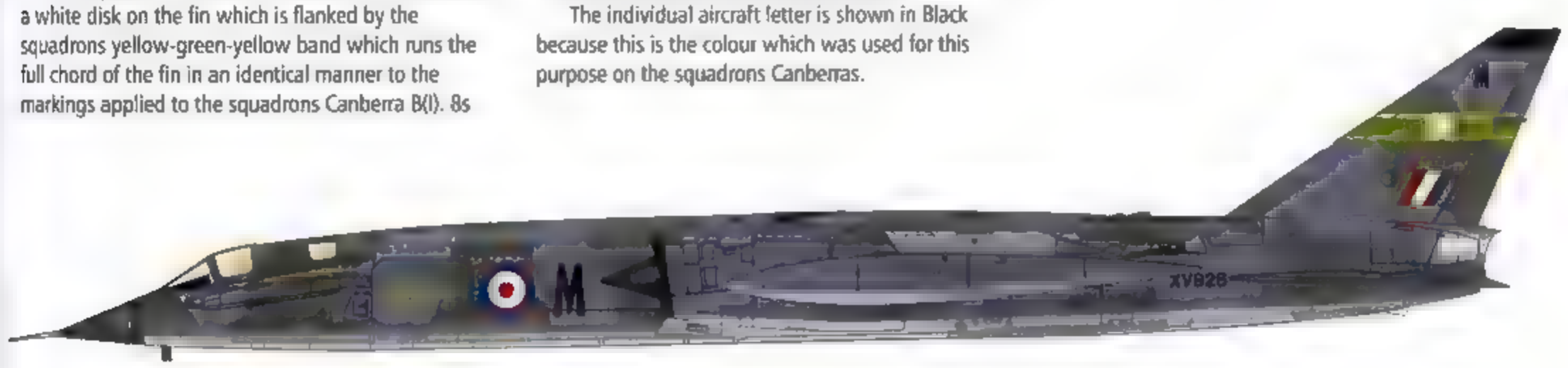


XV926 coded 'M' of 3 Sqn as it might have appeared in 1971 in the 'Spotswood scenario' armed with two WE 177Bs carried internally and carrying two under wing drop tanks

XV926 is another F-111K serial number which might be applicable to a TSR2. XV926 is shown in the standard glossy polyurethane TSR Scheme as laid down in DCI S. DCI S.136/69.

The squadron markings consist of the Cockatrice on a white disk on the fin which is flanked by the squadrons yellow-green-yellow band which runs the full chord of the fin in an identical manner to the markings applied to the squadrons Canberra B(I). 8s which it is suggested that TSR2 would have replaced. The fuselage markings follow the standard practice established for our interpretation of TSR2 squadron markings by having the squadron colours flanking the squadron badge within a standard frame.

The individual aircraft letter is shown in Black because this is the colour which was used for this purpose on the squadrons Canberras.

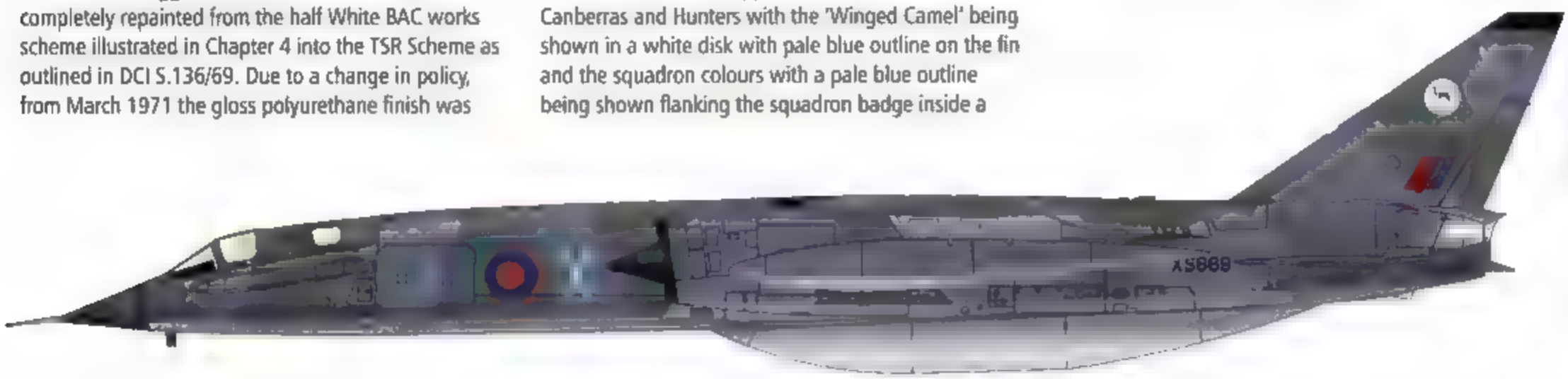


XS669 coded 'X' of 45 Sqn as it might have appeared in 1972 in the 'Spotswood scenario' armed with WE 177Bs carried internally and carrying a full load of drop tanks

It is suggested that XS669 was to have been one of the six of the pre production batch of TSR2s which would be returned to the manufacturers for modification to full production standard following some service with the ODS and or 237 OCU.

As part of this modification to full production standard it is suggested that XS669 would have been completely repainted from the half White BAC works scheme illustrated in Chapter 4 into the TSR Scheme as outlined in DCI S.136/69. Due to a change in policy, from March 1971 the gloss polyurethane finish was replaced by a matt polyurethane finish and White was eliminated from the national markings on camouflaged aircraft. XS669 is therefore shown in an identical matt polyurethane finish to XS668 which is shown as a four view elsewhere in this Chapter.

45 Sqns markings as shown in this illustration are a combination of those applied to the squadrons Canberras and Hunters with the 'Winged Camel' being shown in a white disk with pale blue outline on the fin and the squadron colours with a pale blue outline being shown flanking the squadron badge inside a standard frame on the sides of the fuselage. The individual aircraft letter has been shown in pale blue because it complements the pale blue outlines applied to the squadron markings and because of pale blue's established use as a marking colour.

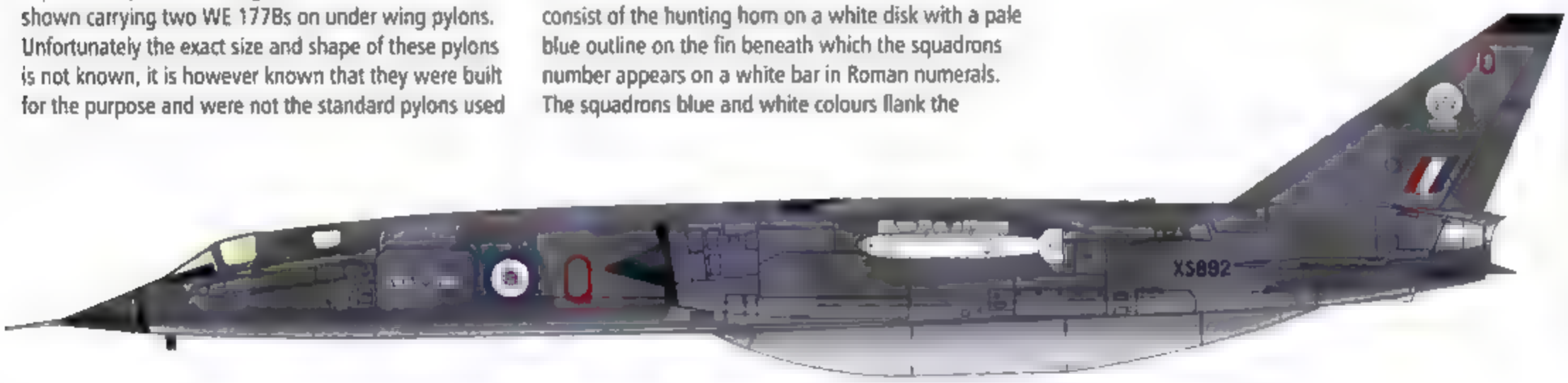


XS982 coded 'Q' of 32 Sqn as it might have appeared between 1969 and 1972 in the 'Spotswood scenario' if 617 Sqn had not been selected as a TSR2 squadron

As noted in the text, because of its seniority, 32 Sqn might have been selected as a TSR2 squadron if the proposal to retain 617 Sqn on the strength of its wartime record had not been approved.

XS982 was one of the batch of TSR2s which BAC expected to produce during 1969 and it has been shown carrying two WE 177Bs on under wing pylons. Unfortunately the exact size and shape of these pylons is not known, it is however known that they were built for the purpose and were not the standard pylons used to carry conventional bombs and rocket pods. The pylons shown here are based on the design of the pylons intended to carry the US Mk. 28 nuclear weapon before this proposal was dropped.

The squadron markings illustrated here are based upon those applied the squadrons' Canberras and consist of the hunting horn on a white disk with a pale blue outline on the fin beneath which the squadrons number appears on a white bar in Roman numerals. The squadrons blue and white colours flank the squadron badge inside a standard frame in the usual place on the fuselage. The individual aircraft letter is shown as being red as this colour was used for this purpose on the Canberras at the same time as the fin markings as shown here.



bomb and was common to all bombing systems. On the other hand, the identification of the target could be affected by the method of delivering the bomb. For example the great majority of targets could not be identified with any degree of certainty unless and until they had been actually passed either directly above or relatively close to on the beam. The definition of 'relatively close' depended upon the height and shape of the target and the degree to which it was masked by its immediate surroundings.

By 1957 it had become apparent that the best means by which a bomber might escape destruction against all forms of ground defences except barrage balloons was by flying low and fast, i.e. below 500 ft and above 0.95M. At these extremes of height and speed a successful attack was thought to depend upon the use of an Identification Point in the near vicinity of the target. With the LABS system which was then under development, the bomber had to enter a steep climb in order to positively identify the target and release the weapon, at which point it became vulnerable to the defences.

The system which Wallis proposed was based on the fact that an aerofoil having a suitable profile would develop lift equally well irrespective of which of its two surfaces happened to be on top. As initially envisioned, a bomb might be fitted with wings of symmetrical profile and a simple tail unit and be carried on the top of a strike aircraft in such a way that as the strike aircraft approached the target or IP it could be raised into a flying attitude then by a suitable adjustment of the longitudinal dihedral between wings and tail the bomb could be made to perform an upward half loop of any required 'g' loading immediately on release.

Furthermore, by means of a simple delay action, this could then be reversed at the top of the loop and by virtue of the wing profile, the bomb would then become a small aircraft flying the other way up and in the opposite direction to the carrier aircraft at the moment of release.

The bomb made its backwards flight by virtue of the momen-

tum derived from the airspeed of the carrier aircraft at the moment of release. A high 'g' loop of small diameter would allow the bomb to retain a large proportion of its initial speed which would allow the bomb to make a rapid dive back at its target at a relatively low altitude. On the other hand a low 'g' loop would lead to a loop of much larger diameter which could be used to allow the bomb to gain sufficient altitude for an airburst.

This method of carrying and releasing the bomb would allow the target to be positively identified at low attitude by flying past it. If the bomber passed directly over the target, the bomb would be released after a certain measure of time had elapsed which would depend upon the height at which the bomb was required to explode, the speed of the bomber on release and the aerodynamic characteristics of the winged bomb. If the bomber passed to one side of the target, then a change of heading would be required to present the target to the tail of the aircraft. The necessary radius of turn, angle of bank and azimuth angle to be turned through could all be readily calculated when the target offset distance, speed of the bomber and desired normal acceleration of the bomber were all known.

No propulsive rocket was necessary at the short release range from the target which would be necessary to ensure accuracy, but much longer ranges could be attained if required by fitting the bomb with a simple type of solid fuel rocket. This would however lead to diminished accuracy.

Air Ministry consideration

The idea of utilising a momentum bomb with TSR.2 appears to have been raised with the Air Ministry in early 1958 as the Directorate of Operational Requirements had studied the proposal and was in a position to pass comment upon it by early March 1958. In a memo dated 11 March 1958 it would appear that the DOR was of the opinion that the proposals for a momentum bomb held both advantages and disadvantages when applied to TSR.2.

Firstly, the point was made that momentum bombing would give a much greater separation distance between the delivery aircraft and the impact than that of loft bombing. In loft bombing however, the separation distance was not a limiting factor in the 60 degree loft. In the 120 degree 'over the shoulder' mode of delivery however, the yield of the weapon would have to be limited to about 1.7 megatons for an aircraft with the performance which was expected from TSR.2. Whilst at the moment the use of megaton weapons in tactical bombers was not contemplated, it was not thought inconceivable that this might become a future requirement and if delivery with LABS were limited to a 60 degree loft, there would be little or no operational flexibility.

Secondly, the external carriage of the momentum bomb at the high Mach numbers which TSR.2 would be flying at would probably make it necessary to introduce some form of skin cooling or air conditioning which would mean the provision of something more sophisticated than the basic idea indicated. Skin temperatures of up to 120 degrees centigrade were anticipated for the aircraft and it was therefore reasonable to assume that similar temperatures would be generated in the skin of the bomb.

Finally, the DOR was of the opinion that momentum bombing appeared to suffer to a great extent from the same tactical disadvantage as LABS in that the aircraft must be headed directly at or be fairly close to the target.

Nevertheless, the idea of equipping TSR.2 with some kind of stand-off weapon persisted as shown by a memo from the Air Ministry to the Ministry of Aviation dated 24 June 1960 which mentions the possibility of providing TSR.2 with some kind of stand-off weapon as a means of helping to justify the high cost which would be incurred in producing the aircraft. The memo does not make it clear what kind of weapon, nuclear or conventional, was envisaged but it would appear that having weighed the advantages and disadvantages of the momentum bomb, the Air Ministry thought the idea worthy of further study and the concept was passed to the RAE for further study. The result was Technical Note No. Arm 678 'Aerodynamic Feasibility Studies for an Unpowered Momentum Bomb' dated November 1960.

The introduction to the note set out the problems of attacking a well defended target at low altitude and went on to set out the rationale behind the momentum bomb which by now had been rethought slightly from the original suggestion in that it was now to be carried internally thus avoiding the kinetic heating problem. However this now meant that the bomb could not be made to fly in the opposite direction to the bomber following release.

The bomb was to have wings fitted to it so that following release at low level the bomb continued to fly forwards towards the target while the aircraft was then free to turn away and escape without climbing. If the bomb was powered by a rocket or other motor then there would be no difficulty in sustaining the bomb's flight sufficiently for the attacking aircraft to release the bomb well clear of the target and escape the effects of the explosion. If the bomb were unpowered and was gradually slowed down by drag the wings would only sustain it until its stalling speed was reached and it was no longer obvious whether it would have sufficient range. In the study, two possible bomb designs were considered and estimates were made of the aerodynamic forces acting upon them and of their likely range and time of flight under various operating conditions.

It was intended that the weapon would have wings and control surfaces and an autopilot to trim and fly it at a constant height. The problems associated with aim and guidance were not considered by the study, nor were the problems which it was thought might be encountered in trying to deploy it from the aircraft at high speed. The aim of the study was therefore confined to showing that such a weapon could have an adequate range and time of flight to allow the releasing aircraft to escape and thus remove the need for it to fly either over or near to the target.

Bomb design

Two weapon layouts were considered each of which had the largest wings which it would be geometrically possible to fit into the TSR.2's weapons bay assuming the wings were of a simple folding design.

The first was of a relatively simple conventional layout with a rectangular wing planform of symmetrical low drag section with a straight trailing edge. This was intended to obtain the maximum wing area within a given span and chord whilst the wing root section was fairly thick to allow space for the wing folding mechanism. This mechanism allowed the wings to fold upwards in order to fit the weapon inside the TSR.2's weapons bay. The body was of a symmetrical low drag bomb design which was expected to be large enough to take any likely warhead, and was fitted with independent all moving horizontal tail surfaces to act as steering controls. It was assumed that the vertical stabilisers would be fixed.

The second design was a canard layout which allowed the bomb to have a much larger wing area whilst still fitting into the space available within TSR.2's weapons bay. Once again the body was of a symmetrical low drag bomb design, but in this instance was of smaller diameter than the first layout. This was because during the design process more information had become available about the size of the warhead it might be expected to carry, this now being smaller than had been assumed for the first design.

It was realised that changing the diameter of the body of the canard design would affect comparisons between the two designs but it was felt that it was more important that any layout investigated should be as close as possible to a likely weapon design.

The wing section was the same as that in the first design with the outer segment of the wings being folded by pivoting about a hinge in the root of the fixed inboard segment of the wing. Independent all-moving forward controls and a fixed vertical stabiliser were assumed.

The aerodynamic characteristics of both designs were esti-

mated with allowances being made for various weapon weights, release speeds, headwinds, turning to attack offset targets, control operation to correct errors, climbing after release from below target level and also climbing to given explosion heights above the target. Most calculations were made for a total weapon weight of 2,000lb but some other weights were also investigated to show the effects of weight changes.

Conclusions

The results of the calculations showed that long ranges were possible for an unpowered momentum bomb released at low level from an aircraft flying at high subsonic speeds. Of the two theoretical layouts considered, the better of the two was thought to be the canard design, its superiority being due to the extra lift produced by the greater wing area and aspect ratio which gave much more manoeuvrability. This would theoretically allow an offset target to be attacked at a range of up to 10 miles with a weapon weighing 2,000lb which could climb to an altitude of 2,000ft above the target before exploding. The launching aircraft could thus always be many miles from the target at the time of the weapon's detonation and thus escape damage or destruction by its own weapon.

There was however one unknown factor which might call the practicability of the whole scheme into doubt, the vulnerability of the weapon itself to the target's defences. The RAE was of the opinion that some kind of vulnerability study needed to be carried out to complement its feasibility study because if the results of the study imposed restrictions on the weapon such as a minimum speed or a maximum time above a given height then the effect on the range attainable with the weapon could be serious.

The results presented by this study were only estimates and it was felt that if a more detailed assessment of the capabilities of a momentum bomb were required then the first step would be to replace the estimated lift and drag calculations with hard data obtained from wind tunnel trials of the particular configurations which were to be investigated. The calculations presented in the report only showed that a momentum bomb was feasible from an aerodynamic point of view and were not accurate enough to optimise a design or give very accurate figures for ranges.

The Momentum Bomb apparently failed to find favour on account of its comparatively short range which meant that the aircraft would still need to be in the near vicinity of the target at the time of the bomb's release, and as a consequence the Momentum Bomb was abandoned.

The Avro W.130

Operational Requirement 1182 is thought to have first been raised in 1960 for a long-range stand-off cruise type weapon to be carried by the V-Bombers in the Strategic Nuclear Deterrent role to supplement or replace Skybolt. There were two submissions to this OR, one by Bristol Aircraft Ltd called the X.12 and one by Avro which was called the W.130, as described in Chapter 2 .

The Avro W.130 proposal failed to find favour with the Ministry of Aviation with the Controller of Guided Weapons and Electronics in particular being scathing about the proposal, describing it as 'a pig in a poke'. At this time Avro were having problems developing the Blue Steel so it is perhaps not too surprising that their proposal for what was in effect a smaller, more sophisticated version went no further

As a tactical missile, the Avro W.130 was perhaps slightly ahead of its time as the following year an RAE Working Party on Air-to-Surface Tactical Weapons was formed in response to a request from the Ministry of Aviation for advice on the subject. Its aims were to assist the Naval and Air Staffs in formulating their requirements for air-launched tactical weapons and to assist the UK representatives in the NATO Weapon Working Group to define their requirements for tactical weapons to be used under NATO auspices.

The scope of the working party was limited to consideration of air-launched weapons carrying nuclear or conventional warheads but excluding biological or chemical weapons. The coverage was also limited to Naval and Air Force weapons and further, did not include anti-submarine weapons.

When the RAE Working Party's interim report was published in June 1962 it concluded that in the nuclear weapons field, the lay-down bomb gave an acceptable mode of attack against lighter defence systems, but that with the build-up of more effective defences, some simple nuclear stand-off weapon would become necessary.

It was recommended that where heavier defences occurred, the possibility of using some kind of target sensor for both nuclear and conventional stand off weapons should be investigated. In the mid term it was suggested that a TV-guided weapon might offer the best prospects, but later lasers or 'O' band radar might have extended applications at night or in some blind conditions. These findings appear to have swiftly brought a response from Industry.

The RAE study apart, the momentum bomb is thought to have been studied only by one other organisation, Bristol Aircraft Ltd who appear to have taken note of the RAE suggestion that if some kind of propulsion were to be added, then any problems about the range of the weapon might be overcome.

The resulting weapon would therefore become a guided missile rather than a bomb and it would appear that following the abandonment of the momentum bomb concept and the interim report of the RAE Working Party, that Bristol Aircraft Ltd adapted their version of the momentum bomb by adding a rocket motor to produce a weapon they named Tychon.

Bristol Aircraft Ltd Tychon

On 10 September 1962 Bristol Aircraft Ltd wrote to the Air Ministry Directorate of Operational Requirements enclosing three copies of their brochure for the Tychon. Dated August 1962, the brochure described the Tychon as being a winged missile for stand-off bombing giving accurate and certain delivery of Nuclear or HE warheads from high speed aircraft which could be delivered from either high or low level and detonated in air or ground bursts in the face of sophisticated defences.

Following release, the parent aircraft would enjoy freedom of manoeuvre which would give it a high chance of success and survival. The concept was stated to permit use at very long range from supersonic or even hypersonic aircraft at high altitude.

Modular construction allowed a weapon to suit almost any tactical strike requirement to be built up from basic units and it was claimed that this versatility would save development costs and effected real logistic economies, whilst the modular approach allowed a degree of built-in 'stretch' potential which would ensure a long service life.

The common units were:

1) The wings
2) The controls and autopilot unit
3) The motor
4) The navigation bay

On to these common components were then attached different warhead components according to role.

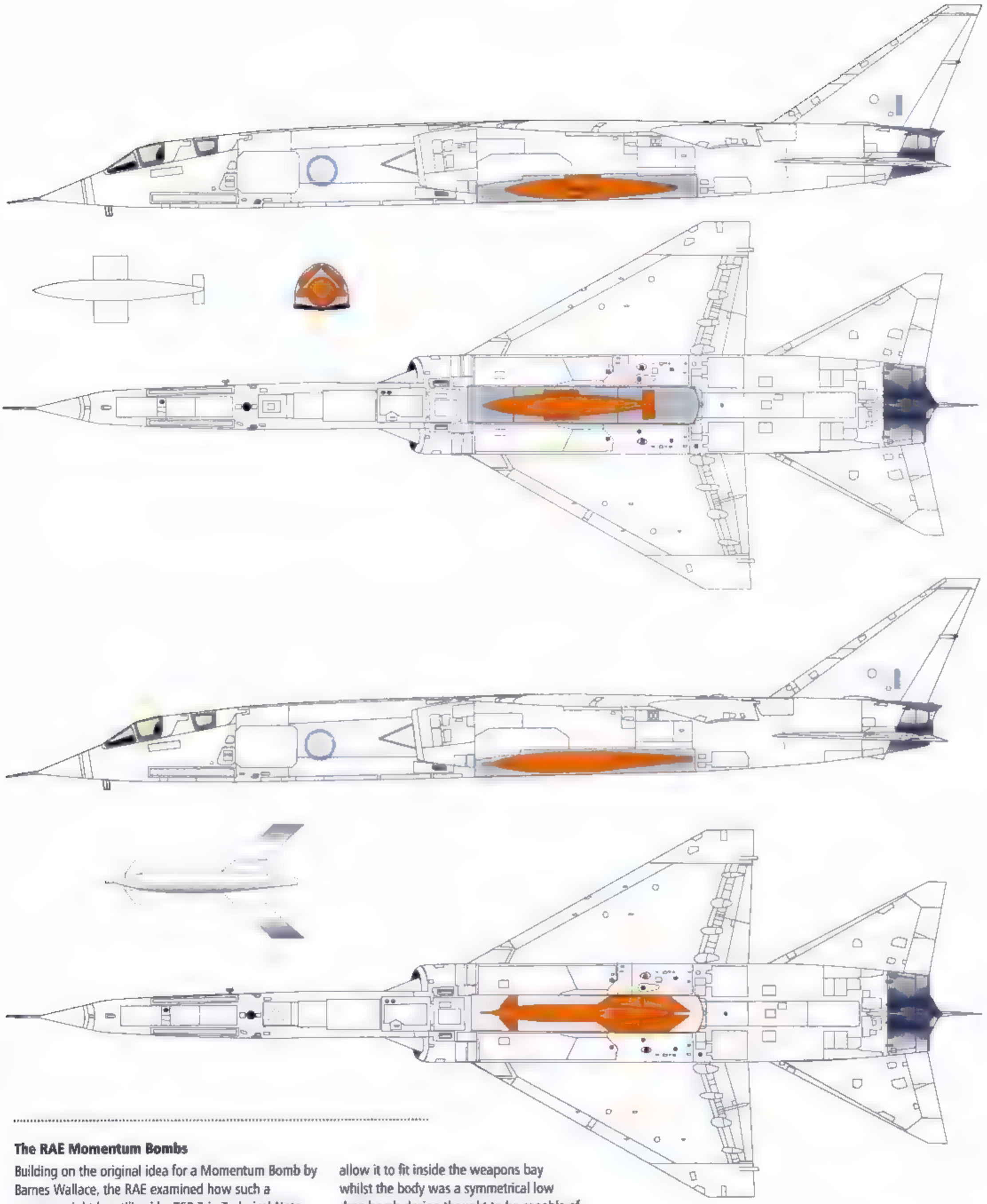
The main variants were:

a) Nuclear
b) HE TV guided
c) HE radar buster

The Nuclear role

At low level in the Nuclear role the Tychon would be capable of being launched at 0.95M at 200ft above ground level.

Stand-off range under these conditions was given as being 12nm for a 3,000ft airburst or 15nm for a ground burst.

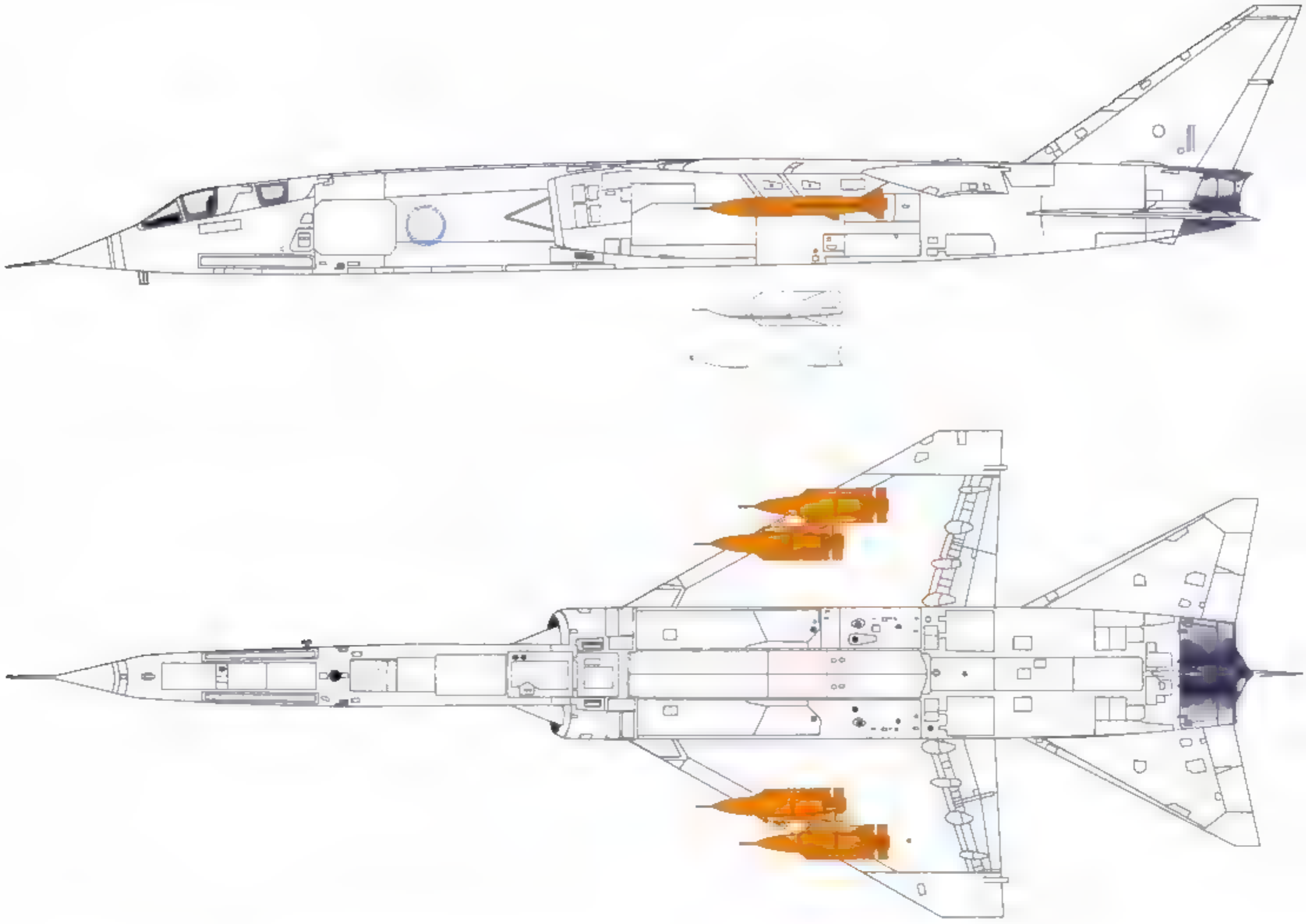


The RAE Momentum Bombs

Building on the original idea for a Momentum Bomb by Barnes Wallace, the RAE examined how such a weapon might be utilised by TSR.2 in Technical Note Arm. 678 'Aerodynamic Feasibility Studies for an Unpowered Momentum Bomb' dated November 1960. Two weapon layouts were considered, each of which had the largest wings which it would be possible to fit inside the TSR.2s weapons bay assuming the wings were of a simple folding design.

The first weapon had a rectangular wing of symmetrical low drag section which folded upwards to allow it to fit inside the weapons bay whilst the body was a symmetrical low drag bomb design thought to be capable of carrying any desired warhead. It had an overall length of 178in with a maximum body diameter of 20in. The main wing had a span of 72in when fully open and a chord of 36in whilst the tailplane spanned 28in with a chord of 12in.

The second weapon had a canard layout which allowed the bomb to have a much larger wing area whilst still fitting into the space available in the TSR.2s weapons bay. This design had an overall length of 155in with the wings folded with a maximum body diameter of 16.8in. The canard spanned 36in as did the main wings when folded though this increased to 96in when deployed. The moving section of the main wing had a chord of 23.5 in.



The Bristol Tychon

In August 1962 Bristol Aircraft Ltd submitted a brochure for a winged missile they called Tychon suitable for stand off bombing. The Tychon was of modular construction which in theory would allow a weapon suited to almost any tactical strike requirement to be built up from basic units.

The common units were

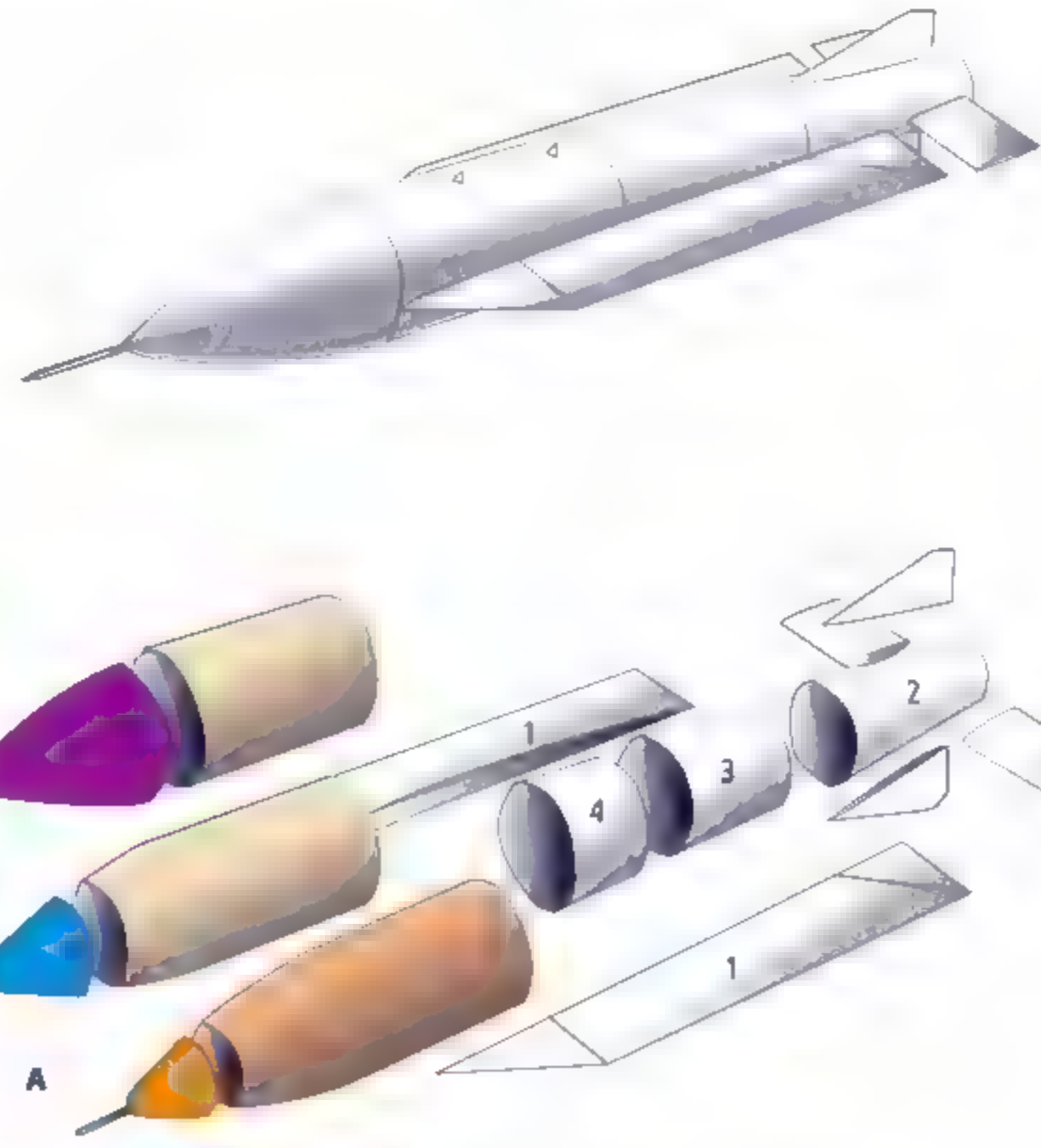
1) The wings
2) The controls and autopilot unit
3) The motor
4) The navigation bay

On to these common components were then attached different warhead components according to role.

The main variants were

a) Nuclear
b) HE TV guided
c) HE radar buster

The Tychon was 140in long (not including the nose probe on the nuclear warhead) had a body diameter of 18in and a span of 36in. TSR.2 was stated as being capable of carrying four, presumably on underwing pylons as shown here.



Aiming was to be either visually, by radar, or other aircraft aiming equipment at either the target itself or by the use of a recognisable offset aiming point.

If released from a range of 5nm Tychon was expected to have a CEP of 90ft plus aiming error whilst at a range of 15nm it was expected to have a CEP of 430ft plus aiming error.

At the other end of the envelope at high level Tychon was capable of being released at M=2 at 40,000ft.

Stand-off range under these conditions was given as being 48nm for a 3,000ft airburst or 50nm for a ground burst.

Aiming was to be as stated above.

If released at 20nm a CEP of 780ft plus aiming error was claimed whilst at maximum range the error was expected to be about 1nm overall.

Under both of these release conditions the parent aircraft would have total freedom of the direction from which it could approach the target and the direction in which it escaped.

The HE TV role

In this role the parent aircraft would navigate to the release point by normal aircraft navigational means.

Once at the release point the operator would see a picture viewed by the TV eye in the missile which scanned the field of view and could be zoomed in to the target area in order to positively identify the target.

Once the target was identified the Tychon would be released under control of its autopilot and navigation computer which received guidance signals from the parent aircraft as the operator kept crosswires on his TV display centred on the target by use of a joystick. The Tychon would then automatically fly to this point. The operator's view of the target was expected to improve right up to the moment of impact. It was suggested that by using this means of attack, the need for post-strike reconnaissance would be obviated.

In the case of a low-level attack it might prove necessary for the aircraft to climb for a few seconds as the missile descended for impact in order to maintain line of sight for the TV command link. It was expected that such a manoeuvre would be completed before the defences had time to react.

The HE radar buster role

In this role the Tychon would lock on to the enemy radar transmission and home on to the radar dish having first navigated to the target by normal means.

Development time scale and cost

It was stated that in the case of a simple nuclear version without terminal guidance it was estimated that service release could be given 4-5 years after the Instruction To Proceed (ITP) was given. Dropping trials would commence 12 months after ITP and system assessment trials 2 years after that. User participation throughout these trials would ensure a smooth transition into Evaluation Trials during the second half of the fourth year of the project.

The prime contractor's cost including the Tychon's Evaluation Trials were estimated at £8 Million.

Versions with terminal guidance could be made available very soon after the simple version as the development time for the terminal guidance system was expected to be comparable with that of the Tychon, but additional trials would be necessary to prove it worked.

Aircraft applications

The Tychon was to be 140 inches long (not including the nose probe on the Nuclear variant) have a maximum body diameter of 18 inches and a span of 36 inches. It was to weigh somewhere in the region of 1,000lb.

Of the aircraft currently in service, the Canberra could carry one whilst the V-Bombers, Sea Vixen and Buccaneer would be able to carry two each. For the future, the TSR.2 would be able to carry four and it was expected that Tychon would also be applicable to the NBMR.3 which ultimately metamorphosised into the Hawker P.1127/P.1154 Kestrel and Harrier. The design was also stated to be suitable for high or low delivery from future generations of military aircraft including the Swallow and sub-orbital bombers.

Future developments were said to possibly include a television version without a warhead which would provide TSR.2 and other aircraft with an expendable reconnaissance vehicle for use over heavily defended targets. This reconnaissance capability could be extended further by fitting a second TV or Linescan in place of the warhead.

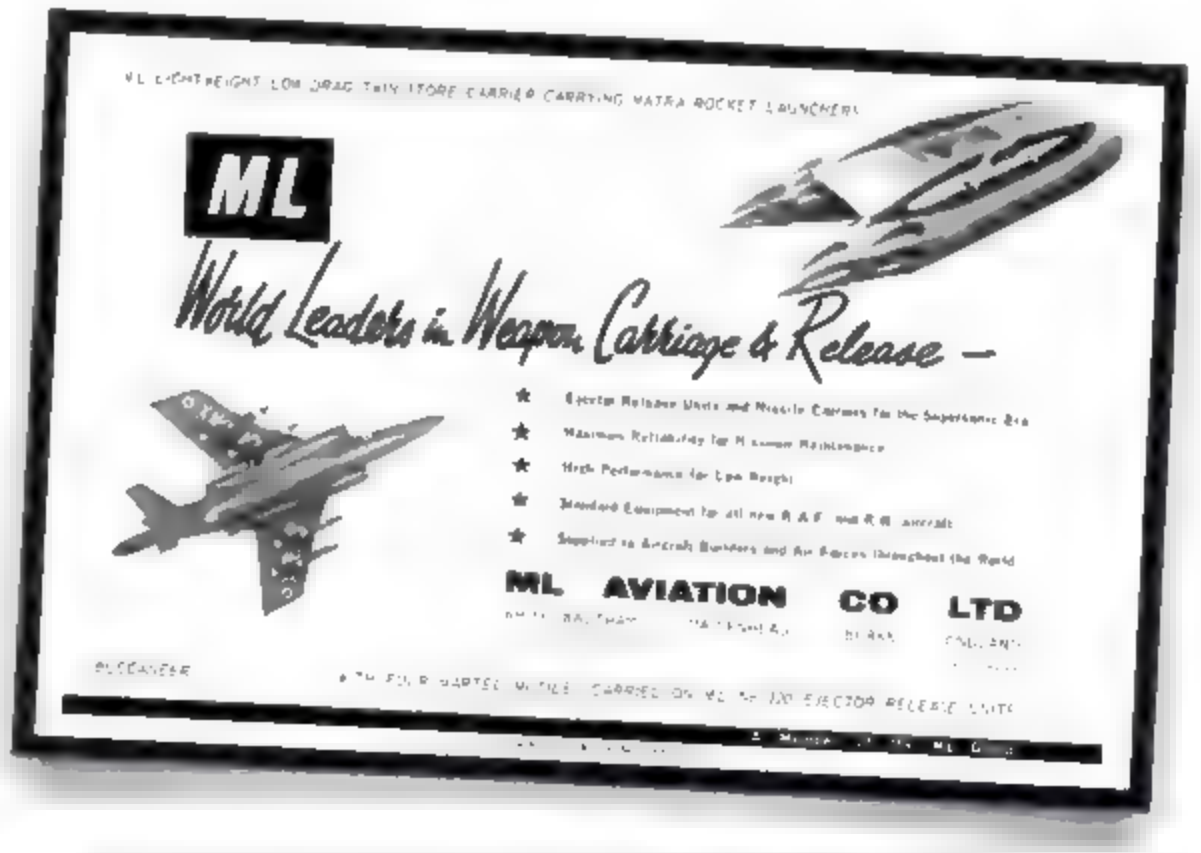
Following the submission of the Tychon for consideration by the Air Ministry this very promising weapon appears to have fallen foul of a combination of not being designed specifically to meet an Air Staff Requirement and bad timing.

1962 had seen the emergence of Operational Requirement 1168 which called for a missile with both anti-radar and TV-guided variants. It would appear that Tychon was an attempt by Bristols to rework their earlier Momentum Bomb design to meet the new requirement.

The stumbling block appears to have been Tychon's 18 inches diameter where AST 1168 called for nothing greater than 16 and a half inches diameter so that the weapon would be compatible with the then standard single point suspension and RAF ejector release units which were used to ensure stores separated cleanly from underwing stores pylons.

In addition to this, the Air Ministry was concerned about delays and subsequent rises in the cost if Britain tried to develop such a weapon by itself. As it happened, the first meeting of a new Anglo French Working Group on Tactical Air-to-Surface Guided Weapons took place on 22 October 1962. On the agenda was a discussion of French views on the requirements of AST 1168, and the Air Ministry was of the opinion that as there was already a close link between BAC and Nord this arrangement might be an advantage if it was decided to launch a collaborative project.

This is what eventually happened as Britain and France launched a collaborative project to meet the requirements of AST 1168 which ultimately became the Martel which never had a nuclear capability. The Martel and other conventionally armed tactical weapons are covered in the next chapter.



A contemporary advert showing the ML Low Drag Twin Store Carrier which is illustrated in the manner in which it might have been used on TSR.2

Chapter 6

The Conventional Strike Role

BESIDES ITS TACTICAL AND STRATEGIC NUCLEAR CAPABILITY within the NATO, CENTO and SEATO context outlined previously, TSR.2 was also intended to allow the RAF to deter and if necessary to fight limited wars using conventional weapons in theatres outside Europe as part of its commitments to maintain the internal and external security of those territories for which it was responsible, to whom there were obligations or in which the UK had essential economic interests.

TSR.2's conventional role would also have taken on added importance within NATO from 1967 onwards when the new strategy of Flexible and Appropriate Response started to be adopted in place of the old 'trip wire' strategy of massive retaliation. The new strategy was intended to present SACEUR with a flexible range of options with the ability to tightly control an escalation from minimum response with conventional weapons to maximum response with conventional weapons according to the level of threat.

Conventional unguided weapons

When the specification to OR 343 which became the TSR.2 was drawn up in 1959 it stated that provision was to be made for the internal carriage of six Mk.6, Mk.9, Mk.11 or Mk.12 1,000lb bombs or not less than six 25lb practice bombs. In addition to this, provision was also to be made for the external carriage of four 1,000lb bombs of the types listed above as well as the 1,000lb Mk.10 and N1 bombs, four pods of 2 inch rockets and a total of twenty-four 3 inch rockets with 18lb heads on standard rails.

Initially, it had been suggested that as 2 inch rockets were considered to be ineffective in all but ideal circumstances, consideration should be given to arming the TSR.2 with guns. It was suggested that it might be more effective to attack many of the targets which would be suitable for a rocket attack with a battery of four 30 mm cannon. The guns would be easier to aim and allow a greater number of attacks to be made than would be possible with salvos of rockets. Furthermore, a gun pack was thought to be likely to impose less limitation on the TSR.2's performance. It was therefore suggested that a study should be made of this question even though it was considered unlikely that a gun pack would have as wide an application as rockets.

It would appear that the study of this question found in favour of the rockets because whilst the specification of the TSR.2 was amended over the next few years with various changes being made to the requirement, no further mention was made of providing TSR.2 with any kind of gun armament.

By late 1963, the conventional armament requirements for TSR.2 seem to have firmed up to the point where they can be usefully described. In a loose minute from the Directorate of Operational Requirements at the Air Ministry to the Ministry of Aviation dated 9 October 1963, the DOR listed the conventional unguided weapons which were to be carried by TSR.2. These were as follows:

a) Internal carriage:
i) Six 1,000 lb. bombs HE Mk. 6, 9, 11, and 12 series with type 100 Mk.6 tails which were to be tail fused with a No.947 Mk.1 fuse
ii) Six 1,000lb bombs HE Mk.6, 9, 11, and 12 series with retarded tails to AST 1194
iii) Six 28lb Practice Bombs
iv) Six 28lb Retarded Practice Bombs to AST 1198.
b) External Carriage:
i) Four 1,000lb HE bombs N1 with Mk.115 tails which were to be tail fused with a No.947 Mk.1 fuse.
ii) Four 1,000lb HE bombs N1 in the retarded role to AST 1194.
iii) Four 36 round Launcher, Rocket, Aircraft No.7 Mk.1 2 inch rocket pods with HE and Tungsten Carbide warheads.
iv) Four weapon dispensers to Joint Naval Air Staff Target 1197.

Bombs, HE, Aircraft, MC, 1000 lb. Mk 6

The TSR.2 was able to carry six Bombs, HE, Aircraft, MC, 1,000lb Mk.6 in its weapons bay mounted in tandem clusters of three as illustrated in the side elevation of the BAC General Arrangement drawing on page 128.

The Mk.6 was a standard RAF bomb which was expected to remain in service for several years and would therefore be available in some quantity, but suffered the drawback of having only one suspension lug which made it unsuitable for external carriage at supersonic speeds. This basic bomb was capable of being fitted with a number of different types of tail. The two different types specified for use with the Mk.6 carried by the TSR.2 were the type 100 Mk.6 and the retarded tail developed to Air Staff Target 1194 which became the Tail, Aircraft, Bomb, No.117 Mk.1 and 2.

Tail, Aircraft, Bomb, type 100 Mk.6 featured extensible fins which allowed the bombs to be closely grouped together inside the weapons bay of an aircraft without their fins fouling each other or alternatively some part of the aircraft structure. Their use on TSR.2 appears to have been necessary by the close proximity of the bombs when loaded in their triple carriers in the restricted space within TSR.2's weapons bay. The extensible fins were deployed after release to give the bombs suitable ballistic properties.

Retarded tail

The Tail, Aircraft, Bomb, No. 117 Mk.1 and 2 was developed to meet the requirement set out in AST 1194 for a retarded

TSR.2's weapons bay from forward looking aft

tail which would slow the bomb down in flight after release at high speed and low level in order to allow the aircraft which delivered the bomb to escape the resulting blast shock wave. The 117 tail was also capable of being used in a high-level ballistic role in which case the retarding mechanism was made inoperative before use.

The retarder consisted of four arms pivoted at the root of the fins which in the closed position formed the outer contour of the tail. When opened, the four arms pivoted outwards and backwards being interspaced with retarder fabric of ribbon construction which effectively formed a parachute which retarded the bomb. Two versions of this tail were made available, the Mk 1 which had a fin span of 23 inches and the Mk.2 which had a fin span of 16.5 inches. It is assumed that had this type of bomb and tail combination have actually been used by TSR.2 then the 117 Mk.2 would have been used internally for the reasons outlined above whilst the Mk.1 would have been used externally.

Some documents mention the possibility of using the Mk.10 Bomb as this was fitted with twin suspension lugs, but no stocks of this bomb were held by the RAF and they would have had to be specially provisioned. With large stocks of the Mk.6 being available, the RAE did not recommend a change in the design of the TSR.2's internal bomb carriers to accommodate twin lugs during the life of the project though this might have happened eventually if the aircraft had actually entered service.

Bomb, HE, Aircraft, MC, 1,000lb Mk.N1 fitted with Mk.115 tail

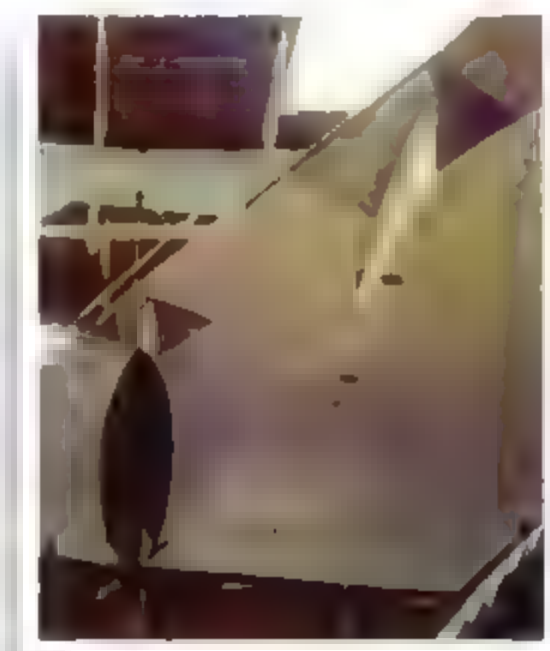
The type of bomb specified for external carriage by TSR.2 was the Bomb, HE, Aircraft, MC, 1,000lb Mk.N1 fitted with Mk.115 tail. This was similar to the Mk.10 in that it was fitted with two suspension lugs which made it suitable for external carriage by supersonic aircraft but was somewhat thinner and longer thus making the weapon as a whole more streamlined.

This type of bomb was used by the Royal Navy who intended to deploy it on Buccaneers but it was not provisioned for the RAF at this time. In September 1963 the Navy held a stock of 400 N1 bombs which was expected to rise to 800 by March 1964. If the RAF were to order the N1 for TSR.2 it was expected that delivery would begin some two years from the date of the production order.

It had originally been intended that a retarded tail to AST 1194 would be developed to fit the N1 but by May 1964 the Ministry of Aviation had formed the opinion that it would be impossible to develop retarded tails for both the Mk.6, 9, 11, and 12 series and the N1 in the timescale required. As a consequence, the decision was taken to prioritise on the tail to fit the Mk.6, 9, 11 and 12 series as described above.

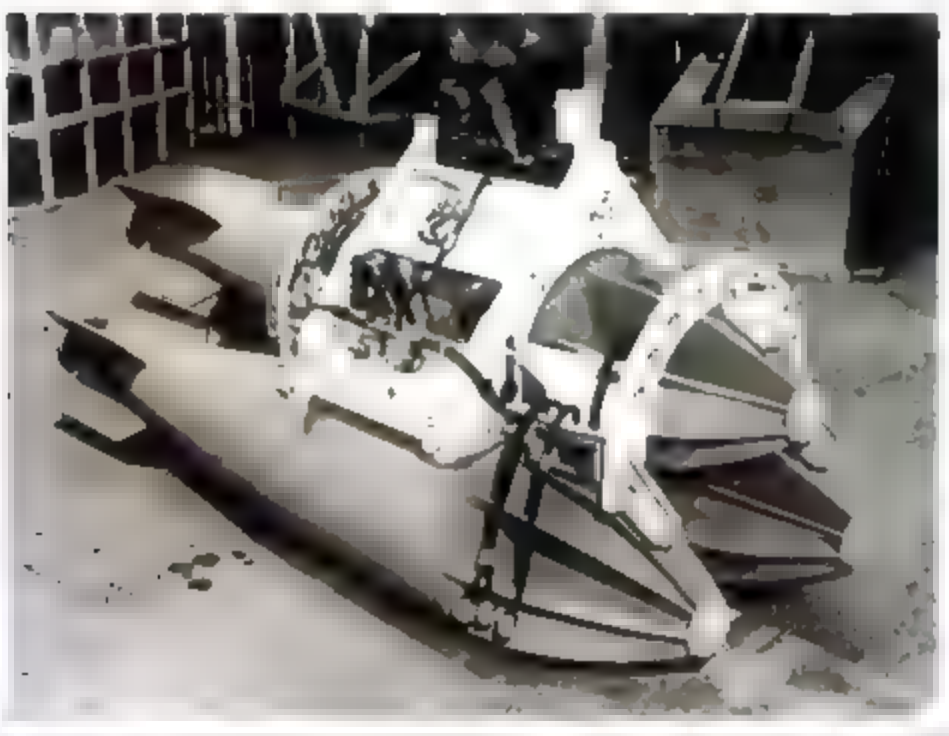
A mock up of the triple Bomb HE Aircraft MC Mk.6 installation for internal use in TSR.2s weapons bay

As far as is known, all these different types of HE bomb and tail combinations would have been coloured overall Dark Green with a single red ring painted around the nose which could be supplemented by a light green ring for Amatol group explosives, a blue ring for RDX group explosives, green and black rings for TNT group explosives, a black ring with a light green ring on each side for Pentolite group explosives and a single broad light green ring for Shellite filled bombs.



A mock up a 1,000lb Type N.1 bomb fitted to the outer standard pylon

To lift the bomb into position a specialist bomb trolley was used



Two of these triple bomb carriers would have been carried in tandem within TSR.2s weapons bay giving a total internal capacity of six 1,000lb bombs

Side view of a mock up of a 1000 lb. Type N.1 bomb fitted to the outer pylon

XV928 coded 'R' of 3 Sqn as it might have appeared in 1971 in the 'Spotswood scenario' armed with six 1000 lb. Mk. 6 bombs fitted with No. 100 Mk. 6 tail units being carried internally and ten 1000 lb. Mk. N1 bombs externally

The six Mk. 6 bombs carried internally were carried in two triple clusters arranged with one bomb above the other two as shown here. The No. 100 tail units had extensible fins which allowed the bombs to be carried in close proximity to each other.

The inboard pylons are speculative in that they are based on a suggestion as to how the TSR2s payload might be increased. The suggestion was that the Martel pylon might be adapted to carry four 1000 lb. bombs though no detail was provided as to how this might be accomplished. Therefore the speculative design shown here has been based on methods used on other aircraft. The exact size and shape of the Martel pylons for TSR2 is not currently known. The inboard pylons illustrated here are based on those designed for the TSR2 and Bullpup combination. This pylon has been furnished with an adapter and a beam similar in design to that fitted to the Buccaneer. The beam carries two ML twin stores carriers which are mounted by the middle of their three sets of lugs in a similar manner to that practised on the under fuselage pylons on the Tornado. Each of the twin stores carriers is then shown carrying two Mk. N1 bombs which were the type specified for external carriage by TSR2. These installations have been aligned with the weapons bay to avoid problems with the centre of gravity of the aircraft when they are released.

The outboard pylons are the standard TSR2 outboard pylons each of which carry a single Mk. N1 bomb.

Bomb load concerns

Initially, each of the wing pylons was to carry a single 1,000lb bomb which along with the six 1,000lb bombs to be carried internally would have given each TSR.2 a bomb lift of ten 1,000lb bombs. This payload seems to have drawn some unfavourable comment from several directions. One example is to be found in a letter dated 27 February 1963 from Vickers Armstrongs to the Directorate of Operational Requirements at the Air Ministry. The letter stated in a facetious vein that it had been noted that the US F-105 Thunderchief was now able to carry 16 x 750lb stores which was of course 2,000lb more than TSR.2. The author of the letter enquired "Why not use triple or tandem carriers on TSR.2? I am sure they would be quite cheap!"

By July 1 1963 it would appear that Vickers-Armstrongs were taking the issue of increasing the payload of the TSR.2 more seriously as on this date a memo on overloading TSR.2 stated that in addition to the current weapon loads on the wings, the firm had to seriously consider the multiple carriage of 1,000lb bombs on each wing store station and the possibility of providing additional stores stations. Whilst the memo makes no mention of where these extra stores stations might be located and action on the issue of providing multiple carriage of bombs on the existing under wing stores stations does not seem to have been rapidly forthcoming, it would appear that action was eventually taken on the issue of multiple bomb carriage on the existing stores stations.

Following the decision to adopt the Martel Air-to-Surface Missile in February 1965, it became apparent that the inboard pylon for this store might be modified at quite modest cost to carry four 1,000lb bombs each. What form this modification would have taken is not known for certain but it is likely that the pylon would be fitted with an adapter and a beam similar to that devised for the Buccaneer which would carry two ML twin stores carriers in tandem in a similar manner to the pylons currently fitted to the fuselage of the Tornado.

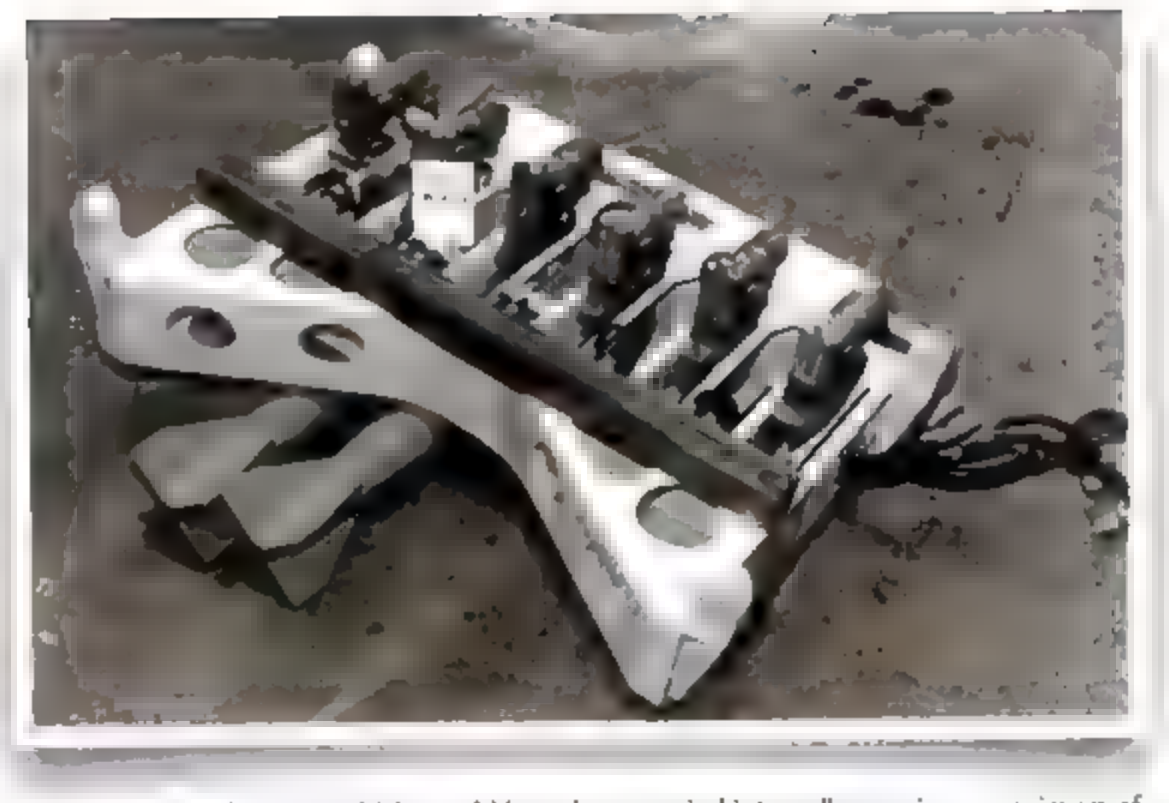
One other possibility for increasing the external bomb carriage of TSR.2 was also apparently considered in the form of the Douglas Triple Ejection Rack (TER). Some concern was raised however with their suitability for use on TSR.2, especially on the inboard weapons station where problems were anticipated with the stores being ejected towards the sides of the fuselage. Whilst it is not clear whether any action was ever taken to provision the Douglas TER for TSR.2, they were subsequently purchased and used on the Phantom. Though trials also took place regarding their use on the Buccaneer, the Douglas TER never seems to have been used operationally on this aircraft.

Practice Bombs

Two types of practice bombs were to be carried by TSR.2, the Bomb, Practice, 28lb Smoke and Flash No.1 Mk.1 and the Bomb, Practice, 28lb Retarded No.1 Mk.1. The No.1 Mk.1 practice bomb was a low drag type of bomb designed for release from high speed aircraft. It was capable of being released at all heights from 100ft. upwards and on impact emitted a puff of smoke and a white flash. Six of these bombs could be accommodated in a special practice bomb carrier which was to be located at the forward end of the TSR.2's weapons bay.

Once the design of the Retarded Practice Bombs to AST 1198 had firmed up in October 1963 it became apparent that with a span of 6.9 inches the drag plates fitted to the Retarded No.1 Mk.1 took up more space than the 6.25 inches span of the Smoke and Flash No.1 Mk.1's fins. This appeared to indicate that it might not be possible to carry six of these stores in TSR.2's practice bomb carrier and that only four retarded practice bombs could be carried.

These practice bombs were initially coloured what the Air Publication of January 1964 describes as a 'light french blue', which was probably BS 381C No.175 Light French Blue with a half inch wide red band approximately seven and a half inches from the rear end to denote that it carried an active agent. However, it would appear that the colour of practice bombs changed circa 1965 as the Air Publication on the retarded practice bombs dated September 1966 gives the colour of these bombs as being 'deep saxe blue' which was probably BS 381C No.113 Deep Saxe Blue.



The practice bomb carrier which would have been carried internally carrying a maximum of four practice bombs

The inboard pylon seen here is possibly intended to carry the standard 450 gal drop tanks as it is equipped with a pair of sway braces which imply carriage of a heavy load

Unguided rockets

An early draft of OR 343 called for the aircraft to deliver rockets in dive attacks with the aircraft flying at speeds of up to 550 knots at low altitude in the Tactical Strike role. Initially the specification called for the internal carriage of either twenty-four 3 inch rockets with 60lb or 24lb heads or alternatively seventy-four 2 inch rockets. The Air Staff thinking behind the use of 2 or 3 inches rockets was in terms of a 'peripheral' war and of targets which would in most cases be only lightly defended. As a consequence the need to climb during the approach in order to visually acquire the target was considered to be acceptable and the vulnerability of the aircraft to the target's defences was not considered to be of overriding importance.

There were considered to be five main types of target:

i) Small Soft Target. Examples of this type of target included thin skinned vehicles, railway rolling stock, mobile electronic equipment on airfields and missile sites, parked fighter aircraft and troops in the open.

ii) Large Soft Target. These were considered to be such things as parked bomber aircraft, and other large airfield targets such as hangars and workshops.

iii) Buildings. In this instance, the attack was to be aimed at the contents of the building rather than its structure, such as personnel, ammunition, fuel, electronics and so on. Light Anti-Air-

The 37 round Launcher, Aircraft, Rocket No.7 Mk.1 forms part of the display of weaponry arranged in front of this Royal Navy Phantom FG.1

craft gun sites also came under this category of target. One further and perhaps surprising type of target fell into this category, small ships. These were considered to be anything from dhows to light naval vessels carrying troops, ammunition, fuel or equipment. Dry hits were expected to be sufficient to sink them or alternatively, destroy their contents.

iv) Armoured Personnel Carriers. These were lightly armoured troop carriers whose primary role as their name suggests was the transport of troops over relatively short distances and on the battlefield.

v) Tanks. It was considered however that tanks would preferably be attacked by a guided weapon and were not therefore seen as being of prime importance for the small calibre unguided rocket.

A study was put in hand by the RAE to assess the suitability of the then extant unguided rocket systems for these tasks. The RAE report on the subject, Technical Note No. Arm 656 which was published in November 1959, stated that multi-rocket installations on high performance aircraft demanded tube launching from a battery in place of the earlier underwing rail installations which were fitted to aircraft such as the Hunter FGA.9. With an internal installation this was seen as being the only practical engineering solution whilst being aerodynamically necessary with an external installation.

This would not cause a problem with the 2 inch rocket because this had been designed for tube launching, but the 3 inch rocket had fixed fins and was launched from a 'zero length' underwing rail. As a consequence, the 3 inch rocket would need to be redesigned before it could be installed on TSR.2 either by replacing the fixed fins with folding fins or by launching it from a helical projector which would give the rocket sufficient spin to ensure accuracy.

When the total number of rockets which could be fired in a single pass from a retractable internally mounted rocket battery and externally mounted rocket pods were compared, for each type of rocket the external pods offered the greater weight of fire. For example it was estimated that TSR.2 would be able to deliver 128 2 inch rockets from a single internally mounted battery whilst it would be able to deliver 148 2 inch rockets from up to four externally mounted pods.

It is thought that the engineering problems associated with the 3 inch rocket and any form of internal carriage along with the greater weight of fire available from externally mounted rocket pods led to the decision being made to opt for the 2 inch rocket in externally mounted pods.

Thus initially the Launcher, Rocket, Aircraft No.7 Mk.1 which contained 36 2 inch unguided rockets was specified for use on TSR.2. However, the 2 inch unguided rocket had originally been designed for air-to-air use and it was recognised that the HE warhead would not be capable of stopping an armoured vehicle such as a tank. This led to the suggestion that a new armour piercing warhead might be obtained or alternatively, an Air Staff Target raised for an improved rocket system.

It would appear that ultimately the decision was made to obtain an improved rocket system as the installation ultimately specified for use on TSR.2 was the Matra 155 68mm (2.68in) rocket with a high explosive warhead which was to be fired from a 36-round pod manufactured in the UK by Thomas French (Special Products) Ltd which also saw service with the Royal Navy and the RAFs Canberra force. The only real problem with this system was that the pods were not stressed for supersonic flight and if carried by TSR.2 this would have imposed performance limitations on the aircraft, though as mentioned above, in a peripheral war this might not be especially important.

Ultimately the RAF acquired the smaller Launcher, Matra, Type M155 rocket pods which were stressed for supersonic flight containing eighteen 68mm SNEB rockets. During the early RAF career of the Phantom in the ground attack role these launchers could sometimes be seen carried in threes on Douglas TERs on the inboard pylons and in pairs on ML twin stores carriers on the outboard pylons of Harriers. During the 1970s these M155 'Matra pod' launchers became a common sight on RAF Hunters, Hawks and Buccaneers. Photographs of any RAF aircraft other than the Canberra with the 36-round launcher are rare, though Buccaneers sometimes carried them early in their RAF careers (presumably being of ex-naval stock like the Buccaneers themselves and possibly only until the introduction of the 18-round pod) and the Harrier was cleared for its use during the Falklands conflict.

The 36-round Launcher, Rocket, Aircraft No.7 Mk.1 pods appear to have been finished in a pale grey colour on their noses with natural metal bodies the rear of which took on a 'burned metal' hue after some use. Ultimately the natural metal areas of the pods were refinished in Dark Green as the 1970s progressed and the RAF began to tone down its aircraft and equipment, though the noses appear to have remained light grey. Initially, the 18-round Matra pods were coloured gloss black on their noses with natural metal bodies like the 36-round launchers, but the natural metal bodies of these pods were also refinished in Dark Green in later years.

Joint Naval Air Staff Target 1197

Joint Naval Air Staff Target (JNAST) 1197 was an attempt to provide both the RAF and Royal Navy with a low-level munitions dispenser which could be used by low-flying, high-speed aircraft against a variety of battlefield targets. Such targets were likely to consist of tanks and armoured personnel carriers, parked aircraft, motor transport vehicles and personnel. The munitions to be carried by the dispenser system were therefore to be anti-tank, anti-personnel, anti-material, smoke and non-lethal incapacity agent bomblets, in that order of priority.

It was intended that JNAST 1197 would be principally used by such aircraft types as TSR.2, Phantom and Buccaneer attacking at speeds of up to .95M at heights of less than 500ft above ground level. A subsidiary requirement was that the dispenser should also be suitable for use by Scimitar, Sea Vixen, Canberra, Hunter and slower aircraft if practicable.

The RAE Technical Report which appraised the various proposed systems in February 1965 indicates that there were three basic designs put forward. The first design, proposed by Westlands, was for a disposable dispenser which was dropped from the aircraft like a conventional bomb. When released from the aircraft, a braking parachute was deployed to reduce the weapon's speed to about 450 knots. A speed sensor then erected four fins arranged around the tail of the dispenser which were aligned at an angle of 15 degrees to the airstream which caused the dispenser to rotate. At a speed of 300 knots the parachute was jettisoned and a proximity fuse would cause the dispenser to eject its bomblets at a set height above the ground which were scattered by the centrifugal force imparted by the spinning motion.

A variation on this idea was to delete the speed sensor, drogue parachute and the proximity fuse, with a simple timer being used to erect the fins and eject the bomblets a set distance below the aircraft.

An alternative means of spinning the dispenser was the use of a radially mounted rocket motor to impart the spinning motion in

XV894 coded 'N' of 237 OCU as it might have appeared in 1971

XV894 is one of the serial numbers allocated to the F-111K which it is suggested might have been allocated to a TSR2 built in 1970 instead had the type actually have gone into service.

This illustration shows a variety of conventional training stores all being carried simultaneously in order to try and illustrate all the stores in the limited space available. The weapons bay is shown accommodating six 28 lb. Smoke and Flash No. 1 Mk. 1 practice bombs at its forward end and four 2[illegible] lb. Retarded No. 1 Mk. 1 practice bombs at its rear end. The different appearance and colour of these bombs can be seen in the scrap views. The Port outer pylon is shown fitted with an 18 tube 68mm Launcher, Matra, Type M155 whilst the Starboard outer pylon is fitted with a TV Martel acquisition training round which allowed the navigator to guide the whole aircraft towards a target as though [illegible] were a TV guided Martel.

TV guided (top) and AR versions of Martel seen side by side. The differences in the seeker heads are readily apparent

place of the fins. In this scheme a timer was to be used to ignite the motor and initiate the ejection sequence for the bomblets.

The second proposal was put forward by Hunting Engineering Ltd, once again in two forms. The first type of dispenser remained fixed to the aircraft whilst the other was a free-falling dispenser. In both cases the method by which the bomblets were to be dispensed was by firing them backwards from axial tubes which were angled outwards at their open ends.

The third proposal was put forward by the RAE itself. In this scheme the dispenser was dropped from the aircraft in the same way as a bomb and detonated by a mechanical timer. Upon detonation, the core of the dispenser would be fired forwards to clear the exterior casing. Once the core was clear, cordite charges inflated rubberised fabric bags around which the bomblets were stowed thus ejecting the bomblets radially.

TSR.2 could carry 6 of any of these designs without any performance limitations or aircraft modifications internally, but external carriage might have imposed either one or the other.

Of all these schemes, the Westland dispenser without the rocket motor seems to have been the originally preferred device, but it would appear that like the TSR.2, it never went into service, possibly on account of the restrictions it placed on the performance of the aircraft when the store was carried externally. Ultimately, the Hunting BL 755 cluster bomb was adopted, entering service in 1972. This has two suspension lugs and is presumably capable of being carried externally at supersonic speeds.

Air-to-surface missiles

In the early 1960s, there were two possible Air-to-Surface Missiles (ASMs) which might be bought off the shelf that would be suitable for application to the TSR.2. These were the US Bullpup which had been selected by the Royal Navy who used it to equip their Scimitar and Buccaneer squadrons, and the French AS 30 which had been selected by the RAF for a number of its Canberra squadrons.

Both of these weapons were considered for application to TSR.2. Bullpup was cited in OR 343 but this was subsequently superseded by the AS 30 as some 930 rounds were already on order for the Canberra and it was considered that there would be a pool of operational experience with the weapon to draw on within the service. The main drawback to the AS 30 however was that it was not a true 'stand-off' weapon as like Bullpup, it depended upon the parent aircraft flying to within visual range of the target to deliver it.

The RAF was already committed to the development of a true stand off weapon to Air Staff Requirement 1168 in conjunction with the French which became the Martel and as the delays with TSR.2 mounted, it slowly became apparent that the projected timescale for the Martel and TSR.2's entry into service dates were slowly converging. It was already known that the work involved in transferring the AS 30 from Canberra to TSR.2 would involve a considerable amount of development work to solve both aerodynamic and stressing problems, as well as producing the necessary special-to-type launching shoe and ejection gun.

Kinetic heating effects would in any case limit the carriage of AS 30 to subsonic speeds whilst the missile's aiming and arming characteristics would prevent the TSR.2 from attacking targets from very low altitudes and thus make the aircraft vulnerable to ground defences. A further consideration was the shelf life of the AS 30. The manufacturers had guaranteed a life of at least a year whilst the Ministry of Aviation considered three years to be a more accurate figure. In any event, unless the entire AS 30 stock were refurbished, their shelf life would expire before TSR.2 had any need of them.

Thus in May 1963 the Standing Committee was invited to approve the cancellation of the AS 30 for TSR.2 on the grounds that ASR 1168 (Martel) would match the TSR.2 in timescale. Cancellation was expected to save £725,000 in development costs plus a minimum of £30,000 for modifying each production aircraft. Thus AS 30 came to be dropped in favour of Martel

Martel

Martel began life as Joint Naval/Air Staff Requirement OR 1165 for an advanced tactical air-to-surface guided weapon in March 1962. It was believed that as tactical aircraft became ever more complex and expensive, there would be fewer of them in relation to the number of tactical targets in a non-nuclear limited war scenario. It was therefore seen as essential that these few aircraft should be capable of attacking their targets with the minimum amount of exposure to defence systems such as highly developed surface-to-air missiles and be capable of destroying the targets with the first attack.

Whilst minimum exposure to the defences was best afforded by a high-speed approach to the target at low level, extant families of air-to-surface guided weapons were not compatible with this technique, as their delivery necessitated the exposure of the aircraft to the ground defences throughout the attack phase. The Naval and Air Staffs therefore required the development of a stand-off air-to-surface guided weapon with a conventional High Explosive warhead capable of a very high degree of accuracy when delivered by an aircraft flying at high-speed at low-level.

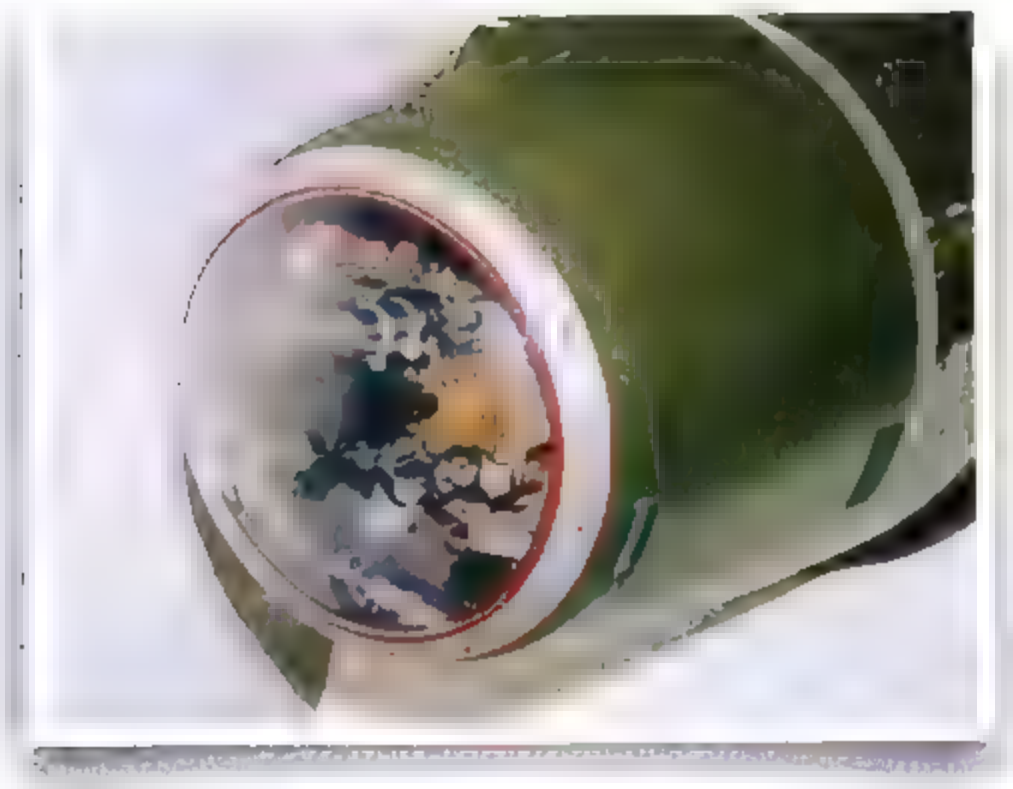
The weapon was to offer a very high probability of destruction or at least of severe damage under daylight and fair weather conditions to targets such as bridges, buildings, radio/radar stations, mobile radars, guided missile launchers, parked aircraft, wheeled, tracked and armoured fighting vehicles and ships. For attacks on various types of radar it was considered desirable that the weapon should have a homing capability, whilst for attacks against shipping an underwater penetration capability was sought.

The weapon was to not weigh more than 1,000lb, was to be suitable for internal or external carriage and the carriage of four weapons by TSR.2 was stated to be 'desirable'.

When it became apparent that the French also had a requirement for a similar type of weapon, the British and French governments agreed to jointly develop the Martel which took its name from Missile Anti-Radar Television. A Memorandum of Understanding was signed by the British Minister of Aviation and the French Minister des Armées on 4 September 1964 with Hawker Siddeley Aviation becoming responsible for the development of the television-guided version whilst Engins Matra were responsible for developing the anti-radar version.

Television command guidance system version

The TV-guided version was to have a semi armour piercing warhead and was intended for use against point targets such as ships, HQ buildings, bridges and tunnels. It was expected that the missile would be launched from an altitude of approximately 200ft though it was to be cleared for use at altitudes of between 50 and 7,500ft at a range of up to 20nm from the target. Britain initially ordered 200 of this version of which 155 were for the RAF and 45 for the Royal Navy, at a cost of approximately £74,000 per missile.



Close up of the Television camera in the nose of the TV guided version of Martel

Anti-Radar version

This version was fitted with a passive radar homing head and HE warhead for stand-off attacks against transmitters operating on S to L bands, pulsed or continuous wave, fixed or variable frequency. It was designed for launch between 50 and 50,000ft at ranges of up to 75nm Britain initially ordered 150 of this version of which 125 were for the RAF and 25 for the Royal Navy at a unit cost of approximately £75,000 per missile.

Whilst the carriage of four Martels by TSR.2 was stated to be 'desirable', in March 1964 BAC was of the opinion that only two weapons could be carried, one on each inboard wing pylon which would preclude carriage of underwing fuel tanks. It was considered that carriage of two Martels on each wing might adversely affect the longitudinal stability of the aircraft, and that further problems might arise as a consequence of carrying two of the missiles so close together, especially in respect of the wingspan of the missile, and detailed study of the problem would be needed.

It was expected that both versions of Martel would be fitted to TSR.2 with the avionics necessary to control the TV-guided version being carried externally somewhere under the fuselage behind the weapons bay which would thus be left free for other weapons, though it is difficult to see exactly where this could be fitted. It is perhaps more likely that the necessary avionics would be loaded into the weapons bay thus leaving the fuselage free to accept a ventral fuel tank. If the operational doctrine of the Buccaneer squadrons which eventually operated Martel is anything to go by, it would appear unlikely that both types of Martel would be carried by the same aircraft at the same time. In a six-aircraft attack, two would carry the AR version whilst the other four would carry the TV version

TSR.2 was of course cancelled long before the Martel project reached fruition. Though production contracts were placed in December 1969 various delays with the missiles meant that training releases for the TV version were not issued until April 1974 and for the AR version in September 1974. The total number of these missiles obtained by Britain is not known and production is said to have terminated in the late 1970s.

Early deliveries of both versions of Martel appear to have been overall Light Aircraft Grey, though as with other types of externally carried ordnance they appear to have acquired an overall Dark Green finish as the 1970s progressed.

Napalm

Political approval for the Royal Navy and RAF to provide their aircraft with a napalm capability was given in December 1964. As this was so close to the cancellation date of the TSR.2, it is thought that little development work was carried out to provide TSR.2 with a suitable Napalm weapon. Initially it would appear that standard 100 gallon drop tanks as carried by Hunters, Scimitars and Sea Vixens were modified into Fire Bomb Gel Type 100 gallon No.1 Mk.1 for use by FAA Scimitars, Buccaneers, Sea Vixens, RAF Hunter FGA.9s and assorted marks of Canberra. It would appear that initially the Fire Bomb Gel Type 100 gallon No.1 Mk.1 was also proposed for use by TSR.2 but concerns were raised about the possible effects of the kinetic heating induced by supersonic flight upon such a flammable payload. If and how these concerns were resolved is currently unknown though it is known that a Naval Air Staff Requirement, NASR 1196, was raised for a napalm bomb suitable for carriage by fast jets by January 1965.

The introduction to British service of napalm was regarded as highly secret at the time as it was seen as being politically sensitive in Whitehall. This sensitivity was due in no small part to the adverse publicity that US use of napalm in Vietnam had received. The secret was revealed by the Torrey Canyon disaster of March 1967. The tanker ran aground on Seven Stones Reef 16 miles from Lands End on 18 March. Attempts were at first made to tow the ship clear but this became impossible as the ship broke into two pieces and began to spill her cargo of crude oil into the sea which began to pollute the Cornish coastline. Following a crisis mini-cabinet meeting of Ministers held at Culdrose the decision was taken to use napalm in an attempt to set light to the oil and thus burn it off. As a consequence the first British operational use of napalm since the Second World War took place on the afternoon of 28 March when Hunters from 229 OCU used it to attack the wreck. The politicians need not have worried about the British public's reaction to the use of napalm. It appears to have been greeted with a metaphorical shrug of the shoulders and the sentiment 'so what?'

Chemical weapons

If the possession of napalm was regarded as highly secret, this was nothing compared with the political sensitivity which surrounded the fact that by the early 1960's, Britain had a reawakened interest in the offensive use of chemical weapons. A memo of the time stated that the fact that the UK had an interest in an offensive Chemical Warfare (CW) capability was particularly sensitive and was to be treated as for atomic matters on a strict need to know basis. Though at the time that OR 343 was being written in the late 1950s there does not appear to have been a requirement for TSR.2 to employ chemical weapons, but had it actually entered service this requirement would have arisen.

During 1962 it became apparent to the British government from information provided by British Intelligence that Soviet military strategy considered the use of CW to be a normal method of waging war which was complementary to the use of nuclear weapons. It was also suggested that this means of making war was seen as being preferable to a nuclear exchange where mobility was required, physical destruction was to be avoided or there was a need to neutralise and occupy an area of land for an extended period of time.

The Anti Radar version of Martel

XV896 coded 'S' of 6 Sqn as it might have appeared in 1971 in the 'Spotswood scenario' armed with eight 18 tube 68 mm Launcher, Matra, Type M155 pods

The 36 tube 2in Launcher, Rocket, Aircraft, No.7 Mk.1 pod was originally specified for TSR2 which would have given the aircraft a weight of fire of 144 rounds. This pod however had the disadvantage of not being stressed for supersonic flight and as a result the RAF obtained the smaller Launcher, Matra, Type M155 68mm 18 tube pod shown here fitted to XV896. This type of pod was a common sight on RAF strike aircraft throughout the 1970s. In order to retain the same weight of fire with the 18 tube pods, it would have been necessary to carry twice as many as previously. The eight Type M155 shown here are attached to ML twin stores carriers which are attached in turn to standard TSR2 pylons.

In order to allow sufficient clearance for all eight pods to be carried in this manner, advantage has been taken of the three sets of mounting lugs fitted to the ML twin stores carriers. The first set is aligned along the carriers centre line. The second set is offset to the left of the centreline and the third set is offset to the right of the centreline.

When the aircraft is viewed from above and behind, the ML twin stores carrier on the inboard pylon is therefore mounted by the lugs which are to the left of centre on the port wing and to the right of centre on the starboard wing, thus moving the stores inboard. The ML twin stores carrier on the outboard pylon is conversely mounted by the lugs which are to the right of centre on the port wing and to the left of centre on the starboard wing, thus moving the stores outboard.

This type of armament was only envisioned as being useful in conflicts of low intensity where opposition and defences would be negligible and the need for the aircraft to climb during the approach in order to visually acquire the target was considered to be an acceptable risk.

CW systems available for tactical use by the Soviets were stated to be ballistic and cruise missiles, freefall rockets and bombs, multi-rocket launchers, land mines, spray devices, artillery shells and grenades.

From where British Intelligence gained this information is unknown though it is tempting to speculate that at least some of it was provided by Oleg Penkovsky, a Colonel in Soviet Military Intelligence who had offered his services to the Secret Intelligence Service (SIS) popularly known as MI6, in 1960. Penkovsky was recruited whilst accompanying a Soviet trade delegation to London during April 1961 and during the next 15 months he passed a considerable amount of intelligence material to the British, some of which is said to have concerned Soviet plans and capabilities for chemical warfare, before he was caught and executed.

In the light of this perceived threat, on 6 November 1962 the Chiefs of Staff Committee recommended a programme of research and development with the aim of providing the UK with a limited retaliatory capability comprising both lethal and incapacitating agents which could be delivered by aircraft with an in-service date of 1970.

Because the need for a CW capability was urgent, air-delivered weapons could take many forms, because they would need to be matched with both existing and future aircraft and on the basis that a lethal agent could be procured quickly whilst more time would be needed to develop an incapacitating agent, in September 1963 the three Service Staffs agreed to pursue the development of an offensive capability in two stages.

The first stage was Joint Naval Air Staff Requirement (JNASR) 1199 for an aircraft spray system fitted with the lethal agent VX for an in-service date of June 1965, whilst the second stage was Naval General Air Staff Target 1203 which tasked a feasibility study for a variety of means of disseminating lethal and incapacitating agents with an in-service date of post 1970.

It was felt that this approach offered a simple and relatively early retaliatory capability within an acceptable time and for an acceptable cost. Part of this was almost certainly due to the ready availability of the named lethal agent 'VX' which had been invented by ICI in 1952 and which had been turned into a weapon by the early 1960's.

Because TSR.2 was not likely to be in service before 1968/9, TSR.2 was not included in the aircraft listed and needing to be equipped with the interim weapon to JNASR 1199. TSR.2 was however included in NGAST 1203 which as envisioned in November 1964 was to provide a capability to disseminate both lethal and incapacitating agents from a wide variety of aircraft for use in anti-riot, counterinsurgency and war operations. Ideally, the weapon system should be compatible with any aircraft which had a ground attack capability with its fitment being sufficiently simple to amount to no more than a role change. Wherever possible the existing bomb carriers, suspension points, sighting and firing system should be used.

Thus the CW system was to be applicable to high-speed tactical aircraft such as the Buccaneer Mk 2, Phantom Mk 2, TSR.2, P.1154 and Hunter FGA.9 and FR.10, medium speed tactical and support aircraft such as the Shackleton Mk 3, Andover and Hercules, low-speed light communications and AOP aircraft such as the Beaver and Twin Pioneer and helicopters such as the Wessex and Whirlwind. The aim was to affect the largest possible surface area from a single aircraft operating within the widest practicable height band, but especially between 50 and 500ft above the ground.

The agents themselves were to fall into four categories, Persistent Lethal for general use in war, Non Persistent Lethal also for use in war but without long-lasting contamination, Incapacitating with minimum lethal effects for use in war where it might be desired to keep casualties low, and Safe Incapacitating which was primarily for use in anti-riot and counterinsurgency operations.

It subsequently became apparent that VX could not be supplied before 1968 and this in turn allowed more time for the development of a more universal weapon suitable for long term use. This effectively gave rise to an entirely new requirement which continued under NASR 1199.

A prototype spray to NASR 1199 was first flown on Hunter F6 XG290 during the summer of 1964. These tests were subsequently extended by further trials in January 1966 to clear the installation for carriage by the Hunter FGA.9 and by analogy the Hunter T.8.

During the period 1964-68, the politicians appear to have continually put off making a final decision as to whether Britain should actually go ahead and acquire an offensive CW capability. As a consequence the project to NASR 1199 and NGAST 1203 does not appear to have progressed much further before the Chiefs of Staff decided that a decision on the acquisition of CW weapons should be postponed for two years in February 1968. As far as is currently known, this decision appears to have brought an end to British intentions to field an offensive CW capability.

TSR.2 evaluated for other roles

Besides the Tactical Strike role for which it had been designed and the stop-gap deterrent role with laydown bombs which it had thrust upon it, in the latter half of 1963 TSR.2 was also evaluated by the RAF Directorate of Operational Requirements for its potential use in the close-support and interceptor roles. This evaluation would appear to have been instigated as a response to the emergence of the apparently multi-role General Dynamics TFX/F-111 which was to be produced in a Fighter as well as a Strike version which in Britain was thought to be apparently capable of undertaking the close-support role as well.

In Britain, the question of using TSR.2 as a Hunter replacement in the close-support role had already been studied by the Chiefs of Staff who had concluded that a smaller aircraft was essential to supplement the TSR.2. It was thought that it would not be possible for TSR.2 to provide the quick reaction close-support which the VSTOL P.1154 would be able to provide for the Army. Even the politicians could see the wisdom of this as Denis Healey reputedly said something to the effect that using TSR.2 to destroy tanks would be like cracking a nut by dropping a television on it!

Nevertheless, an evaluation was carried out and on 27 November 1963 the DOR sent a summary of its findings of an initial evaluation of TSR.2 in what is described in the covering letter as the 'Direct Support' role to a number of departments within the Air Ministry. The evaluation was presented in note form under the headings set out below.

TSR.2 in the Close Support Role

The range and endurance was stated to be better by an order of magnitude than any other aircraft considered for this task. Ferry range was 3,800nm plus a flight refuelling capability whilst the navigation fit allowed full use of the range.

With full internal tanks and 4,000lb weapon load the take-off requirement was 3,000ft. For a 450nm low-level sortie the requirement was 1,700ft. Landing requirement at normal landing weight was 1,600ft. The TSR.2 could be on standby for two to three days and then carry out one operational sortie without technical support. All the necessary support equipment for a 30-day detachment was air transportable by Beverley, Argosy or Andover.

The weapon load was expected to consist of the following:

Either

a) 2 nuclear weapons

or b) 10 X 1,000lb (which might be increases to 14) freefall bombs

or c) 4 rocket pods (which might be replaced by 4 cluster bombs)

or d) 4 Air-to-Surface Guided Weapons to OR 1168 (Martel).

These weapons were expected to be delivered to fixed targets of known co-ordinates with the following CEPs:

At the time that the TSR.2 was being considered as an interceptor, the RAF's front line aircraft in this role was the Lightning. The Red Top which armed many of these aircraft was also considered as the armament for TSR.2 as an interceptor

Nuclear
Blind – 1,600ft when delivered from high level and 750ft when delivered from low level.
Visual – 380ft from a dive or toss manoeuvre executed from up to a maximum of 20,000ft and 320ft from low-level.

HE freefall
In this case there was no blind capability but it was thought that this could be arranged quite easily to give similar accuracy to that for the nuclear weapons given above. When dive bombing with the final dive being carried out under visual conditions below 3,000ft CEP would be between 60 and 200ft.

Rockets
The four rocket pods would at this time have been the 36 round Launcher, Rocket No.7 Mk 1 pods whilst the reference to cluster bombs was presumably a reference to the proposed weapons which eventually emerged to JNAST 1197, all of which have been described previously.

Martel
As this weapon would be guided by TV this could only be used under visual conditions with a CEP of 10ft. It was noted that a blind capability would require new development.

Against targets of opportunity the present capability with rockets and freefall bombs was similar to that of the proposed weapons system proposed for the P.1154 in a dive attack. An attack carried out from low level presented a new problem which would need investigating. Martel was again expected to have a CEP of 10ft.

In conducting a visual search and reconnaissance the TSR.2's minimum loiter speed would normally be about 300 knots, but full manoeuvrability would only be possible down to 400 knots though this could be reduced to 250 knots by the use of flaps. Some further reduction might be possible by the employment of flap blowing but poor handling would make this of doubtful benefit. A sophisticated autopilot would free the pilot's attention whilst the canopy being planned for the trainer would give the navigator a useful view with only minor penalties in TSR.2's performance at low level. However, the trainer canopy might lead to a major reduction in the performance of the aircraft at high altitude.

The reconnaissance fit and ability remained unaltered from the strike role and was expected to perform in an identical manner.

Following the submission of this initial evaluation, the matter was investigated further and a draft paper was prepared by the DOR in early December 1963. The paper concluded that the TSR.2's performance outside its optimised low-level high-speed role was considered to be limiting. It was thought that it would be unreasonable to fly at speeds below 300 knots as at such speeds the TSR.2 would have very poor manoeuvre control.

The TSR.2's conventional weapons aiming system was designed to release 1,000lb bombs or 2 inch rockets in a shallow dive. As a result, the HUD did not permit sighting at speeds of less than approximately 400 knots and would therefore need modification. For stores such as the bomblet dispensers and retarded HE bombs which were delivered from straight and level flight, a new sight was suggested.

Vulnerability

Working on the assumption that the TSR.2 would have to be flown at between 3,000–5,000ft and 350 knots during an attack, it was clear that the aircraft would be very vulnerable to both light anti-aircraft guns and low-level SAMs.

Target acquisition

Studies conducted by the RAE appeared to show that with average visibility a 50 percent chance of recognition of small targets such as tanks or other vehicles could be expected at slant ranges of up to about 2nm. If the aircraft's altitude was reduced to 500ft the acquisition range would reduce to about 1nm.

At lower speeds the aircraft would be forced to adopt a nose-up attitude which would give the pilot a reduced forward view and the navigator none. Whilst the fitting of a 'bubble' canopy would improve the navigator's side view, this would not be sufficient to justify its adoption as it would have an adverse effect on the high-speed, high-altitude performance of the aircraft. In any event, it was more important that the pilot's view be improved as he needed to acquire the target before it could be attacked.

It was concluded that by using flaps it was possible for TSR.2 to loiter over the battlefield at speeds of between 250–350 knots though the aircraft would have very poor handling characteristics. The low speed and nose-up attitude that the aircraft would therefore have to adopt would render the HUD as currently fitted ineffective and make the aircraft unacceptably vulnerable to ground fire, whilst target acquisition would be very difficult.

TSR.2 as an interceptor

The first suggestion that TSR.2 might also find a role as a Fighter seems to have originated at Vickers in the preliminary survey of weapons for the GOR 339 aircraft dated 31 December 1958.

Section 4 was headed 'Air-to-Air Weapons' and stated that in this section of the study, consideration would be given to weapons and equipment which would be required for a possible Fighter version of the GOR 339 aircraft.

Two types of air-to-air weapon were considered suitable for this aircraft, Red Top and Genie. Both had good jump-up capability which enabled targets flying at up to 65,000ft to be attacked. The main technical difference between the two was that Red Top was an infrared homing weapon of high accuracy and having a HE warhead whilst the Genie was unguided and had a nuclear warhead which was believed to have a yield of about 1.5 KT. Long-range guided weapons with nuclear warheads were currently under development in the USA such as the Eagle and Hughes GAR-9, but insufficient information about them was available for an assessment of their application to GOR 339. It was thought that a similar new weapon which would be suited to the GOR 339 aircraft could be developed, however no assessment had been carried out by Vickers on such a weapon.

It was considered dangerous to rely entirely on defensive weapons with nuclear warheads because political considerations would probably prohibit their use in limited warfare. Furthermore, their employment would impose limits on the height and position of interceptions which could be made without the danger of collateral damage. In addition, an unguided weapon might not prove accurate enough to ensure a high kill probability against very high-altitude targets because of the decreasing blast effect of even nuclear warheads as the atmosphere thinned at higher altitudes. For these reasons, it was considered that Red Top should be used,

XV940 coded 'H' of 12 Sqn as it might have appeared in 1975 in the 'Spotswood scenario' armed with four TV guided Martels and carrying a 1,435 gallon ventral drop tank

XV940 might have been one of the last batch of ZD TSR2s BAC expected to produce during 1971 and therefore might have been finished in matt polyurethane had this finish been introduced for TSR.2 from March 1971 as discussed in the main body of the text. In addition to this, it is assumed that by 1975 the national markings would have been modified to the red and blue variety shown here.

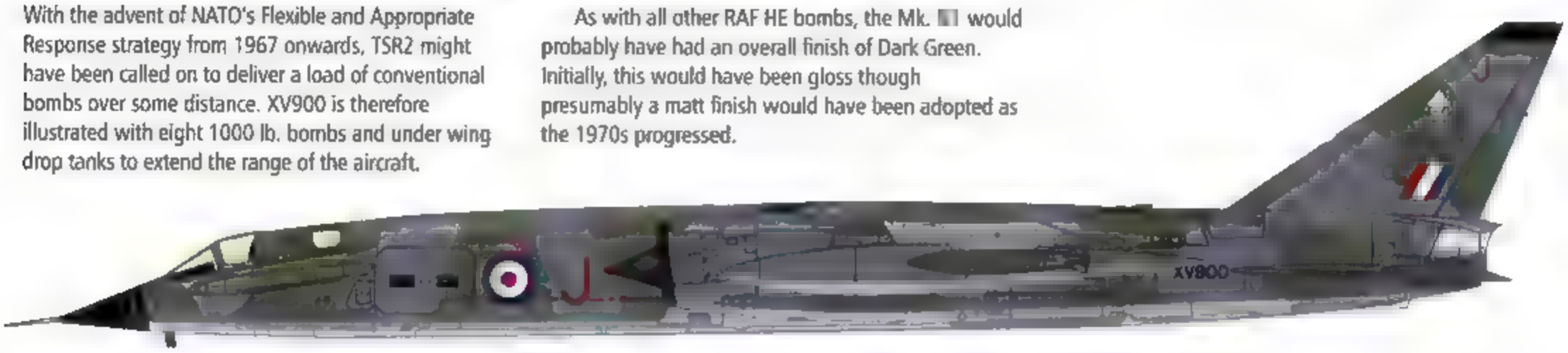
It should be noted that the exact size and shape of the Martel pylons for TSR2 is not currently known. The inboard pylons are based on those designed for the TSR2 and Bullpup combination whilst the outboard pylons were inspired by the 'backwards' Martel acquisition round pylon seen fitted to the Buccaneer. This has the advantage of ensuring adequate separation between the missiles which is known to have been a cause for concern at one stage.

Both types of pylon are seen fitted with an ML No. 120 Ejector Release Unit as also used on the Buccaneer and Martel combination. It is assumed that the avionics necessary to provide the TV link between the missile and the aircraft are being carried internally in the weapons bay though there was a suggestion that they should be carried externally somewhere under the rear fuselage, perhaps in a pod similar to that carried by the Buccaneer.

XV900 coded 'J' of 617 Sqn as it might have appeared in 1972 in the 'Spotswood scenario' armed with six 1000 lb. Mk. 6 bombs fitted with No. 100 Mk. 6 tail units being carried internally and two 1000 lb. Mk. N1 bombs being carried externally

With the advent of NATO's Flexible and Appropriate Response strategy from 1967 onwards, TSR2 might have been called on to deliver a load of conventional bombs over some distance. XV900 is therefore illustrated with eight 1000 lb. bombs and under wing drop tanks to extend the range of the aircraft.

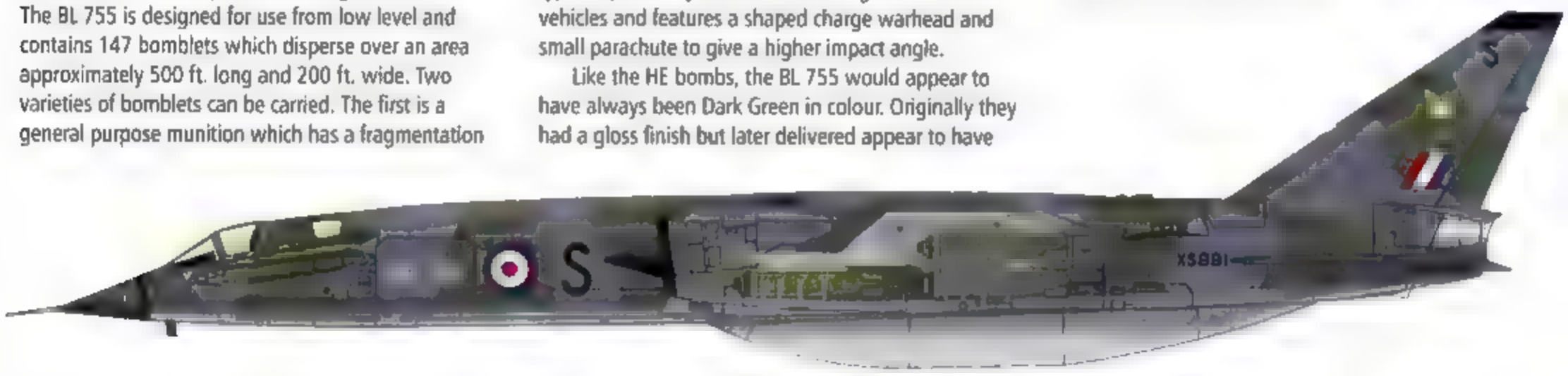
As with all other RAF HE bombs, the Mk. [redacted] would probably have had an overall finish of Dark Green. Initially, this would have been gloss though presumably a matt finish would have been adopted as the 1970s progressed.



XS991 coded 'S' of 14 Sqn as it might have appeared in 1972 in the 'Spotswood scenario' armed with sixteen BL 755 Cluster Bombs with six being carried internally and the remaining ten being carried externally

The [redacted] 755 entered service in 1972 following the abortive attempt to develop a weapons dispenser system to Air Staff Target 1197 during the mid 1960's. The BL 755 is designed for use from low level and contains 147 bomblets which disperse over an area approximately 500 ft. long and 200 ft. wide. Two varieties of bomblets can be carried. The first is a general purpose munition which has a fragmentation warhead intended for use against soft targets such as aircraft, SAMs and unarmoured vehicles. The second type is specifically intended for use against armoured vehicles and features a shaped charge warhead and small parachute to give a higher impact angle.

Like the HE bombs, the BL 755 would appear to have always been Dark Green in colour. Originally they had a gloss finish but later delivered appear to have switched to a matt finish, no doubt in line with the change in aircraft finishing policy which began to take effect from 1971 onwards.



XS954 coded 'Z' of 32 Sqn as it might have appeared between 1969 and 1972 in the 'Spotswood scenario' if 617 Sqn had not been selected as a TSR2 squadron

As noted in the main body of the text, because of its seniority 32 Sqn might have been selected as a TSR2 squadron if the proposal to retain 617 Sqn on the strength of its wartime record had not been approved.

XS954 is illustrated carrying the 36 tube 2in Launcher, Rocket, Aircraft, No.7 Mk.1 pod originally specified for TSR2. This type of pod was also carried by the Canberra and Buccaneer in RAF service and by the Buccaneer and Sea Vixen in Royal Navy service. As far as TSR2 was concerned, its main disadvantage was that it was not stressed for supersonic flight, a factor which is thought to have led the RAF to adopt the 18 tube Matra M155 pod for most of its fast jets.

Some of the 2in Launcher, Rocket, Aircraft, No.7 Mk.1 pods which served with the Buccaneer force had by the mid 1970s had their natural metal areas painted Dark Green, though the nose caps appear to have remained the original pale grey colour.

though a Genie type weapon could also be used if economic considerations would allow.

Red Top was thought to be likely to have good performance at high and medium altitudes, but its performance would be degraded by the obscuration of the target's infra-red source by clouds. Thus for low altitude interception some form of radar guidance would be necessary. A study had apparently been made by de Havillands and GEC of a CW radar semi-active homing version of Red Top, but Vickers believed that this project was not being proceeded with. It thus appeared that a Fighter version of the GOR 339 should carry a mixed load of infra-red homing Red Top and radar-homing Blue Dolphin missiles. Blue Dolphin was actually a developed version of Red Top which was to have a standardised missile body and control surfaces but an interchangeable CW radar and infra-red guidance system. On the face of it, this would allow a Fighter version of GOR 339 to be armed with just Blue Dolphin missiles. Ultimately, Blue Dolphin was cancelled in March 1958 following problems with the radar guidance system.

Whichever type of weapon was used, the aircraft would have to have a long-range airborne interception radar capable of operating in jamming conditions. A developed AI 23 Airpass 2 system could be used but if Blue Dolphin was adopted then CW would be required and this might involve a lightweight development of the AI 18. Because of the change from a terrain clearance to AI radar and various required changes to other items of equipment, the conversion of the GOR 339 from a Strike aircraft into a Fighter would not be a rapid process. It would appear that the idea of a Fighter version of GOR 339 went no further at this time.

The 1963 evaluation

As mentioned above, TSR.2 was evaluated as an interceptor by the DOR during the latter part of 1963 at the same time as the aircraft was evaluated in the close-support role.

The first look at the question of TSR.2 as a Fighter which was sent to the Assistant Chief of the Air Staff in November 1963 suggested that in the Air Defence role TSR.2 would have an excellent rate of climb and rate of roll. Maximum altitude at subsonic speed was expected to be 38,000ft whilst the maximum useful height was 45,000ft at a speed of M=1.2 though the absolute ceiling was likely to be 52,000ft. There appeared to be no obvious snag in fitting Red Top but this would involve a role change and the AI fit would need a design study. There were problems anticipated with the available amount of space in both the nose and cockpit and the probable reduction in terrain-following capability. The whole idea was thought to require much more study. The covering letter which accompanied the notes described the AI/Red Top problem as 'a very grey area'.

As with the close-support role, a more detailed examination of the problem was made and a draft paper prepared in December 1963.

Airborne Interception capability

The forward-looking radar fitted to TSR.2 could not be used for airborne interception in its existing form as it needed to be modified to give a wide azimuth scan and a selectable elevation scan. In addition to this an AI radar needed a power output four times greater than that of TSR.2's radar which with its existing power would give it a range of between five and ten nautical miles which was equivalent to the performance of a 1945 vintage AI Mk.10.

It was considered a more reasonable proposition to take one of the P.1154 AI proposals and to fit that to TSR.2 instead. These radars had a combined Strike and Airborne Interception function, but performance in each role was reduced and it was thought likely that an ideal compromise would be difficult to achieve as it was necessary to retain the automatic terrain-following capability for TSR.2's primary low-level strike role.

Ultimately, the type of radar selected would be dictated by the type of target TSR.2 would be expected to intercept. To intercept a high-flying supersonic target, a long-range AI radar would be needed which would be a CW radar as opposed to the pulse type required for strike operations. It was thought that such a radar might possibly be developed, but not before 1970.

A further factor in obtaining a good AI capability was the size of the radar dish. For a good AI capability, a large radar dish was required. The P.1154 proposals were for a dish of 27 inch diameter compared with TSR.2's 18 inch wide dish. The installation of a larger dish in TSR.2 would probably require a redesign of the nose and radome. However if a reduced AI capability was acceptable then the simpler P.1154 radar which was expected to be available by 1968 might be found to be compatible with the existing TSR.2 structure.

Irrespective of the type of radar adopted additional equipment associated with the AI facility would have to be fitted. For example, both pilot and navigator would need cockpit displays. Whilst it might be possible to cater for the pilot by a modification to the Head Up Display and the navigator by redesigning the Plan Position Indicator the navigator would also need a control stick with which to direct the radar.

Air-to-Air Missile capability

Assuming that its carriage and control could be made compatible, it was felt that Red Top could make up for some of TSR.2's failings as an interceptor. Red Top had a maximum launch speed of M=2 and a maximum speed of M=3.4. It could be fired between 2,000 and 12,000 yards from the target and had a 'snap up' capability of 15,000ft making interception up to an altitude of 65,000ft possible.

With a length of 137.5 inches and a weight of approximately 400lb it was possible to carry Red Top externally on TSR.2 but the missiles would need an AI output similar to that from the AI 23B fitted to the Lightning F3. In addition an AI computer and pilot and navigator displays and controls would be required.

Whilst no documents which illustrate a possible Red Top fit on TSR.2 have come to light, it is possible to speculate that the fit of the missile on the underwing pylons would possibly have been facilitated through the use of a launching shoe similar to that designed for the F-4K Phantom in 1965. Following the Royal Navy's decision to procure the F-4K as its Sea Vixen replacement the question of its armament arose. The standard F-4J version upon which the British F-4K version was to be based could be armed with up to six AIM-7 Sparrow missiles, four semi-recessed under the fuselage and two on underwing pylons as its main armament, and four AIM-9 Sidewinders also on underwing rails as its secondary armament. The F-4K however had the underwing Sparrow option deleted to save weight and it was suggested that in their place the F-4K might carry Red Top as its secondary armament as this was an all aspect weapon whereas the Sidewinders of the day were much less capable weapons and the Royal Navy already held some stocks of Red Top for the Sea Vixen. As a result of this pro-

The Red Top was intended to be used to engage a supersonic target from head on

posal a mounting was designed to allow Red Top to be mated to the under wing pylons on the F-4K which contained all the services which Red Top would require, such as the coolant for the seeker head and the fire control system.

Ultimately in August 1965 however, a recommendation was made to the Admiralty Board that the Sidewinder 1C be adopted as the secondary armament for the F-4K, largely on the grounds of cost as Red Top was stated to cost £18,000 per missile compared with between £3,500 and £3,900 per missile for Sidewinder.

Manoeuvrability at altitude

TSR.2 was of course designed for optimum performance at high subsonic speeds at low altitudes and its performance became degraded at altitude. To maintain level flight at altitudes above 38,000ft the TSR.2 had to be flown at supersonic speed. Even when flown at its normal maximum speed of M=2.05 its 1g ceiling was only about 52,000ft at combat weight. TSR.2's turning circle at altitude was poor. For example at 50,000ft and M=2.05 it was 20nm and necessitated the use of the afterburners to avoid falling out of the sky whilst at 36,000ft and .98M the turning circle was 5 nm. using maximum dry thrust. Thus from an aerodynamic viewpoint TSR.2 itself could not intercept above 50,000ft at speeds in excess of M=2.05 and whilst a sophisticated and 'tolerant' air-to-air missile might go some way towards making up for these deficiencies, the system as a whole could not be considered to be acceptable. It was concluded that TSR.2 would make a poor interceptor.

Evaluation conclusions

In conclusion, the draft paper of December 1963 stated that the US had managed to combine the roles of low-level strike and interceptor aircraft in similar basic airframes by the use of different radar systems and the use of variable geometry. As the TSR.2 was developed for low-level high-speed strike, it was thought to be unreasonable to expect it to perform these 'new' roles as well without undergoing a radical redesign, perhaps to the extent of invalidating the TSR.2 as it was then conceived.

As far as is known, no further questions were raised about the possibility of using TSR.2 as a Close Support or Fighter aircraft prior to the project being cancelled in April 1965.

Strike Camouflage and markings 1969–1972

DCI S.126/66 as discussed previously was replaced by DCI S.136/69 dated 13 August 1969. This new DCI made no significant change in the camouflage and markings of TSR aircraft which were to remain finished in gloss polyurethane Dark Green BS 381C 641 and Dark Sea Grey BS 381C 638 on their upper surfaces with the under surfaces finished in Light Aircraft Grey BS 381C 627. National markings remained Post Office Red BS 381C 538 White and Roundel Blue [illegible] 381C 110 and serial numbers were to be Black. A change was on its way, however.

From gloss to matt

Gloss finish polyurethane paint was introduced for RAF aircraft from 1965 because of its superior adhesion, durability and performance under Nuclear, Biological and Chemical conditions which allowed some measure of ease in the decontamination processes when compared to other contemporary paints. Once applied to an aircraft, it was expected that the finish would have a service life of between five and seven years.

When polyurethane was first introduced it would appear that it was technically difficult to produce a matt polyurethane finish and it was not until the spring of 1968 that a change to a matt polyurethane finish was suggested as a result of operational experience gained with tactical transport helicopters in Borneo. A proposal was made that the upper surfaces of the rotor blades and the under surface of the fuselage, both of which were a light grey colour, should be refinished in Dark Green and Black respectively with HQ Air Support Command and HQ Far East Air Force also suggesting that a matt finish be introduced. At this time, matt polyurethane was apparently undergoing tests with the Directorate of Chemical Inspection but it was thought that if the suggestion was to be acted upon, then supplies might be available within six months.

In the event, it was decided that matt polyurethane would not be adopted at this time, but by December 1968 matt polyurethane had cleared its trials with the Directorate of Chemical Inspection having been found to be just as resistant to chemical weapons as the gloss finish and being no more likely to erode. The matt finish was found to have some shortcomings such as being easily scratched and being more difficult to clean as it retained grease, but these were felt to be outweighed by the operational advantage of reduced visibility, and a service trial on a number of reconditioned Wessex helicopters was put in hand.

This trial seems to have taken some time to get under way as it was not until mid 1969 that the first Wessex was apparently given a matt finish. An interim report was produced which showed that the matt finish had a lower reflectivity and thereby offered a more effective camouflage finish. In addition to this, trials carried out in RAF Germany with some of the first Harriers to enter service clearly illustrated that a gloss finish significantly detracted from concealment when they were dispersed in 'hides'. It was therefore immediately decided to capitalise on the operational advantages of the matt finish and to accept the possible limitations which might be revealed by the final trials report, and the decision to adopt a matt finish for the Harrier and Wessex was made in December 1969.

In mid-April 1970 the Ministry of Technology submitted a favourable report on matt polyurethane. It had been found that a matt polyurethane finish might be expected to be as durable as a gloss finish, having a five-year life. The paint was expected to stand up to normal wear, cleaning appeared to be satisfactory and no engineering problems were envisaged, and in a loose minute dated 23 April 1970, the Assistant Chief of the Air Staff (Operations) stated that he now thought that it was time to adopt matt polyurethane for all camouflaged RAF aircraft and would ask the Director General of Engineering to put this into effect.

The financial cost and the loss of aircraft from front line duties mitigated against an immediate repainting programme for all existing aircraft and therefore with the exception of the Harrier it was accepted that the changeover to a matt finish would take place on a need-to-refinish basis. As the expected service life of the gloss polyurethane finish was between five and seven years, this would inevitably mean that the transitional period between gloss and matt finishes would be a protracted one. Therefore it was decided to prioritise the change so that the aircraft which would gain the most benefit would be treated first and it was decided that Harriers which had been finished in gloss polyurethane were to be refinished in matt at their first major servicing. This was to be accomplished by scuffing down the original gloss finish before repainting with the matt finish. In service repainting of Harriers was to begin from 1 January 1971 with the first new production Harriers in matt finish, from the sixty-third production aircraft onwards, being expected to be delivered in March 1971.

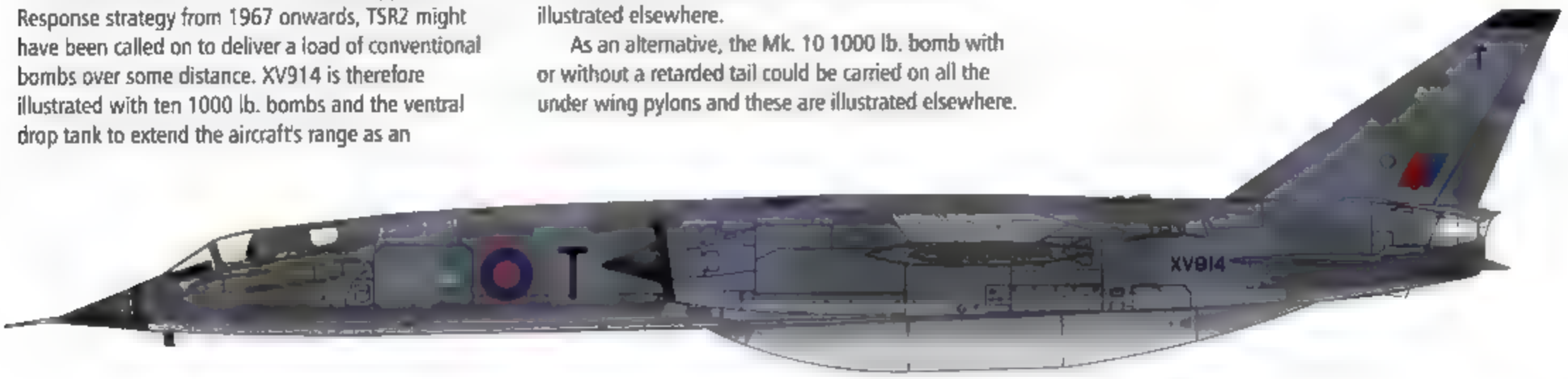
The Chief of the Air Staff does not appear to have been very impressed with the five- to seven-year timescale which was being suggested for the refinishing of the RAF's camouflaged aircraft. On 17 September 1970 in a memo to the Vice Chief of the Air Staff he expressed the opinion that this was "not on" and suggested that the VCAS pursue the matter of the adoption of a matt finish "ruthlessly". The eventual outcome is not known with any degree of certainty, but it is known that over the next few years the matt polyurethane finish did become widespread on RAF aircraft.

During 1971 besides manufacturing the Harrier, Hawker Siddeley

XV914 coded 'T' of 9 Sqn as it might have appeared in 1972 in the 'Spotswood scenario' armed with six 1000 lb. Mk. 6 bombs fitted with No. 100 Mk. 6 tail units being carried internally and four 1000 lb. Mk. N1 bombs being carried externally along with a 1,435 gallon ventral drop tank

With the advent of NATO's Flexible and Appropriate Response strategy from 1967 onwards, TSR2 might have been called on to deliver a load of conventional bombs over some distance. XV914 is therefore illustrated with ten 1000 lb. bombs and the ventral drop tank to extend the aircraft's range as an alternative configuration to the 617 Sqn aircraft illustrated elsewhere.

As an alternative, the Mk. 10 1000 lb. bomb with or without a retarded tail could be carried on all the under wing pylons and these are illustrated elsewhere.

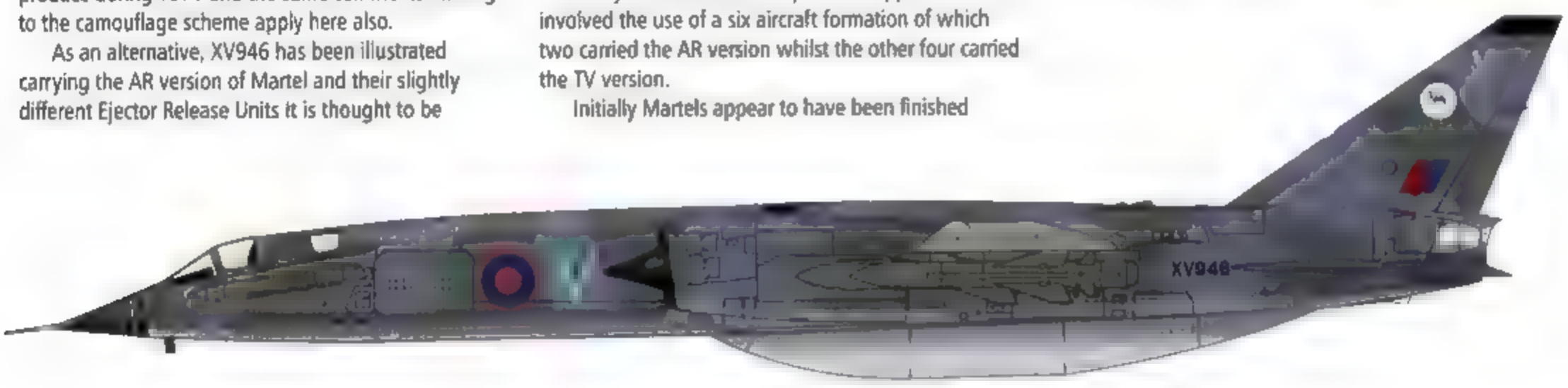


XV946 coded 'V' of 45 Sqn as it might have appeared in 1975 in the 'Spotswood scenario' armed with four Anti Radar Martels and carrying a 1,435 gallon ventral drop tank

Like XV940 illustrated elsewhere, XV946 might have been one of the last batch of 28 TSR2s BAC expected to produce during 1971 and the same comments relating to the camouflage scheme apply here also.

As an alternative, XV946 has been illustrated carrying the AR version of Martel and their slightly different Ejector Release Units it is thought to be unlikely that a single aircraft would carry both types of missile simultaneously as RAF tactics for the use of Martel by Buccaneer Strike squadrons appears to have involved the use of a six aircraft formation of which two carried the AR version whilst the other four carried the TV version.

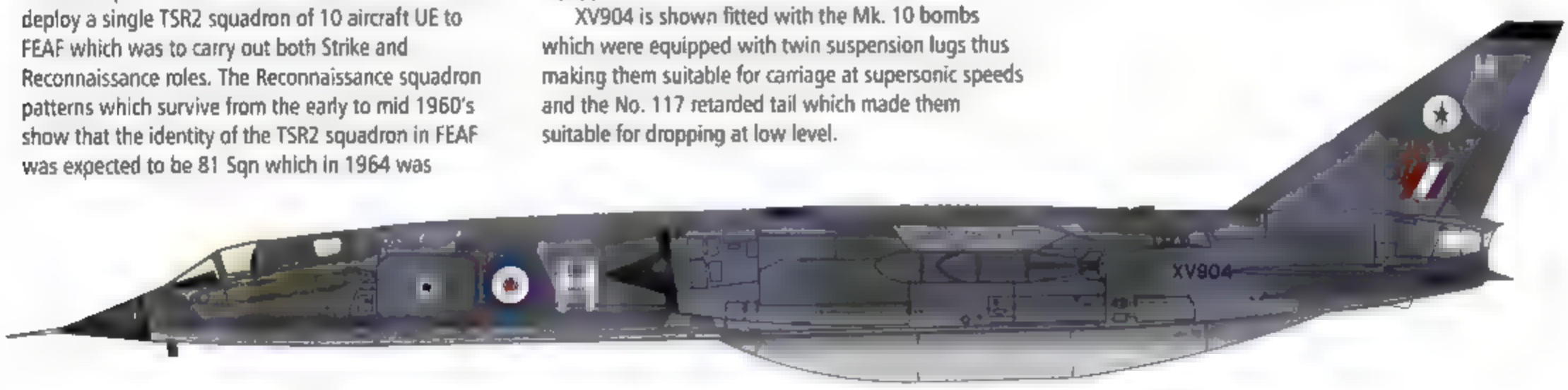
Initially Martels appear to have been finished overall Light Aircraft Grey. However, it is thought that later deliveries were overall Dark Green.



XV904 coded 'H' of 81 Sqn as it might have appeared in 1972 under the provisions of Plan 'P' of March 1964 armed with six 1000 lb. Mk. 6 bombs fitted with No. 117 Mk. 2 Retarded tail units being carried internally and four Mk. 10 bombs fitted with No. 117 Mk. 1 Retarded tail units being carried externally

Under the provisions of Plan 'P' it was intended to deploy a single TSR2 squadron of 10 aircraft UE to FEAF which was to carry out both Strike and Reconnaissance roles. The Reconnaissance squadron patterns which survive from the early to mid 1960's show that the identity of the TSR2 squadron in FEAF was expected to be 81 Sqn which in 1964 was equipped with Canberra PR.7s at Tengah.

XV904 is shown fitted with the Mk. 10 bombs which were equipped with twin suspension lugs thus making them suitable for carriage at supersonic speeds and the No. 117 retarded tail which made them suitable for dropping at low level.

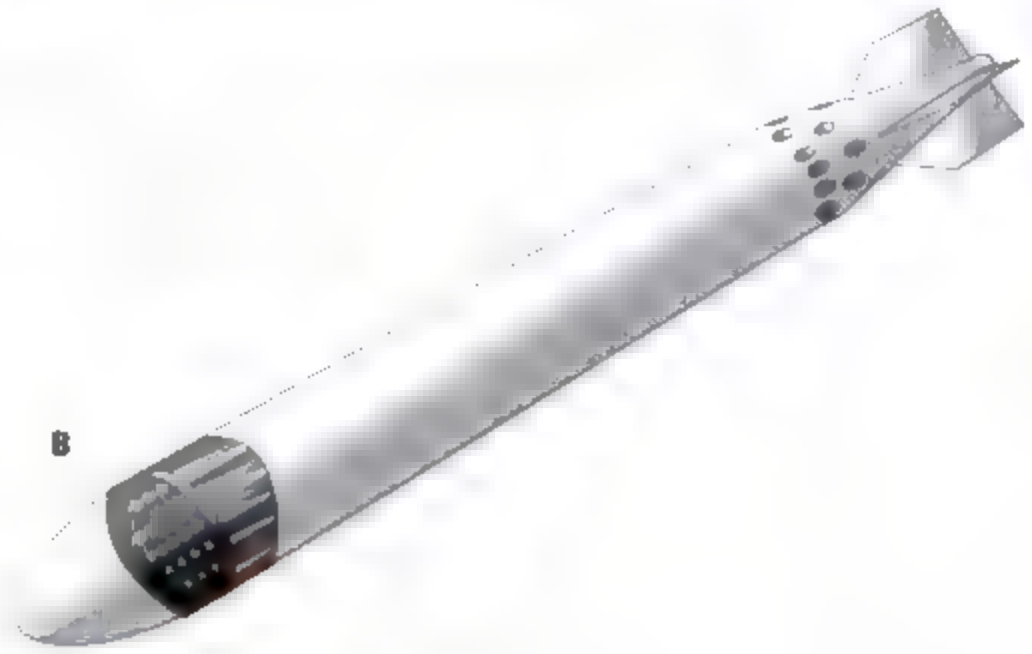


Scrap view of deployed retarded bomb
The retarder device consists of four arms which are pivoted at the root of the fins and interspaced with retarder fabric of ribbon construction. In their closed position the arms form part of the outer contours of the tail which when opened are restrained by nylon strops. The retarder fabric between them is restrained by terylene rigging lines connected to the edge and central vent of each quadrant of fabric. All the strops and rigging lines are anchored to the tails base ring where it is connected to the bombs body.

Proposals to JNAST 1197

Joint Naval Air Staff Target (JNAST) 1197 was an attempt to provide both the RAF and Royal Navy with a low level munitions dispenser which could be used by low flying, high speed aircraft against a variety of battlefield targets. The RAE Technical Report which appraised the various proposed systems in February 1965 indicates that there were three basic designs put forward. TSR2 could carry 6 of any of these designs without any performance limitations or aircraft modifications internally, but external carriage might have imposed either one or the other.

A



B

C

A
The Westland type 1a
This was a disposable dispenser which was dropped from the aircraft like conventional bomb. When released from the aircraft, a braking parachute was deployed to reduce the weapons speed to about 450 knots. A speed sensor then erected four fins arranged around the tail of the dispenser which were aligned at an angle of 15 degrees to the air stream which caused the dispenser to rotate. At a speed of 300 knots the parachute was jettisoned and a proximity fuse would cause the dispenser to eject its bomblets at a set height above the ground which were scattered by the centrifugal force imparted by the spinning motion.

An alternative means of spinning the dispenser was the use of a radially mounted rocket motor to impart the spinning motion to the dispenser in place of the fins. In this scheme a timer was to be used to ignite the motor and initiate the ejection sequence for the bomblets. Both anti tank and anti personnel bomblets were proposed for this weapon.

Both variants of the Westland dispenser were to have an overall length of 110in and a diameter of 16.55in maximum all up weight was to be 1000lb with fragmenting bomblets and 812lb with shaped charge bomblets.

B
The Hunting Engineering Ltd Type 2a free falling dispenser
This dispenser was designed to carry 336 shaped charge bomblets or 168 fragmenting bomblets. It was to be constructed from five separate units which were to be stowed separately and assembled when required to keep within the maximum sub assembly length of 74in required by the Royal Navy. When fully assembled, the dispenser was to have an overall length of 158in, diameter of 17.5in and a maximum all up weight of 1000lb.

A smaller version of this dispenser (Type 2b) was also proposed which carried 114 shaped charge or fragmentation bomblets. The overall length of this version was to be 96in with a diameter of 16.5 in and an all up weight of approximately 500lb.

C
The RAE proposal
In this scheme the dispenser was dropped from the aircraft in the same way as a bomb and detonated by a mechanical timer. Upon detonation, the core of the dispenser would be fired forwards to clear the exterior casing. Once the core was clear, cordite charges inflated rubberised fabric bags around which the bomblets were stowed thus ejecting the bomblets radially. This dispenser was to contain 231 shaped charge or fragmenting bomblets. It was to have an overall length of 98in, diameter of 16.5in and a maximum weight of 1000lb.

were also manufacturing 26 Buccaneer S2.Bs in the serial number range XW525-XW550 which were delivered between January 1970 and April 1973. XW529 delivered in September 1970 had a gloss finish whilst XW541 which was delivered in December 1971 appears to have had a matt finish but retained the red, white and blue national markings, which provides a further illustration of the matt finish being introduced from the spring of 1971.

It was during the spring of 1971 that the national markings also began to undergo a change, with the upper wing and fuselage roundels as well as the fin flash losing their white segments and thus becoming equally proportioned red and blue markings. Like the shift from gloss to matt polyurethane, this change also appears to have been a protracted one. Though the changes to a matt finish and red and blue national markings began in the spring of 1971 these changes do not appear to have been promulgated to the service until the following year.

DCI S.70/72

DCI S.136/69 was replaced by DCI S.70/72 dated 26 April 1972 which introduced the new matt finish and toned-down national markings for TSR aircraft. Though the finish was now to be matt, the colours themselves remained unchanged with the upper surfaces of TSR aircraft remaining finished in Dark Green BS 381C 641 and Dark Sea Grey BS 381C 638 and the under surfaces Light Aircraft Grey BS 381C 627.

Roundels and fin flashes on aircraft bearing disruptive camouflage patterns were to be coloured Post Office Red BS 381C 538 and Roundel Blue BS 381C 110 whilst those on other aircraft were to remain Post Office Red, White and Roundel Blue as previously. This wording might have given the impression that the new red and blue markings were to be applied to disruptive camouflaged surfaces only, so for some time, aircraft could be seen with the red and blue markings on the upper surfaces and red, white and blue markings on the under surfaces. Eventually however the new red and blue markings spread to the Light Aircraft Grey under surfaces as well.

As far as TSR.2 is concerned, the BAC production schedule of 1968 expected 28 TSR.2s to be manufactured during 1971. This works out at 2.3 aircraft per month and by the time that the new matt polyurethane finish might have been introduced from about March 1971, 7 of these aircraft would already have been produced. Whether any change would have taken place in finish of the remaining 21 aircraft to leave the production line during 1971 is therefore open to question, especially in light of the decision to prioritise the introduction of the new finish to the Harrier and Wessex which would have had first call on what would probably have been a limited supply of the new finish. It is therefore assumed that BAC would have already purchased a sufficient stock of gloss polyurethane for all production TSR.2s and that this stock would have been expended before the introduction of a matt finish on BAC's next mass produced aircraft type, the Jaguar.

Nevertheless it is theoretically possible that the last 21 TSR.2s might have received a matt polyurethane finish. If this had been the case, it is likely that they would still have been marked with red, white and blue national markings like Buccaneer XW541 which was delivered in December 1971.

Chapter 7

The Reconnaissance Role

WHEN OPERATIONAL REQUIREMENT 343 WAS DRAWN up for a Tactical Strike and Reconnaissance aircraft, all-weather Tactical Reconnaissance by both day and night was defined as an alternative role for the aircraft of equal importance to Nuclear and Conventional Strike. OR 343 stated that in the Reconnaissance role the aircraft was to obtain reconnaissance information for all tactical purposes, including target mapping at low altitudes using radar and/or photographic methods. In order to increase the flexibility of the weapons system, a medium-altitude reconnaissance capability was also required.

The reconnaissance system was to be installed in a detachable pack, or if necessary two detachable packs, and was to consist of a Sideways Looking Reconnaissance Radar (SLRR), Linescan equipment and its associated data transmission equipment and finally, more traditional reconnaissance equipment in the form of vertical Photographic Cameras.

The servicing time needed for changing roles from Strike to Reconnaissance and vice versa was to be as short as possible and was to be less than six hours under airfield servicing conditions.

Reconnaissance TSR.2s and Global Nuclear War

As the TSR.2 was capable of being operated from a variety of airfields it could be easily dispersed. When nuclear war appeared imminent, each TSR.2 squadron would on the declaration of the alert probably be dispersed on the basis of two aircraft to an airfield to avoid destruction on the ground. Whilst no reconnaissance backing beyond the normal servicing arrangements was necessary to launch the reconnaissance aircraft, recovery of these aircraft must be made to an airfield to which processing and interpretation facilities had been deployed. Ideally, all airfields to which the aircraft were dispersed should be provided with these facilities but it was thought that it might only be possible to equip two airfields for each squadron. Strike aircraft would recover to airfields at which weapons had been prestocked and processing facilities would therefore have to be made at these airfields.

In nuclear war, the initial reconnaissance was expected to be preplanned and would mainly be concerned with target acquisition and damage assessment of the enemy delivery systems i.e. to assess the effects of the first strike upon the enemy and to check the level of activity at various targets before a strike by 'second wave' aircraft. The importance of this role was directly related to the restrike/second strike capability, and reconnaissance sorties in this role were seen as being likely to be mainly carried out at low level owing to the effectiveness of the air defences, though it might be necessary to fly high/low/high profiles if this was necessary to reach the more distant targets.

In the main therefore, the reconnaissance would be limited to low level oblique photography, sidescan radar and to Linescan. Reconnaissance by the strike aircraft would be a by-product of their main task, but pre- and post-strike reconnaissance could be carried out en route to and from the target.

At one point it was suggested that the Home Office might also require a post-enemy-strike reconnaissance of the UK to be carried out, but it is not clear whether this ever became a firm requirement, let alone to what extent TSR.2 might have been employed in this task.

Reconnaissance TSR.2s and Limited Wars

Apart from nuclear war, it was thought that TSR.2 might have to carry out conventional operations in any part of the world. The nature of these operations would depend upon the area and the nature of the opposition. However, in view of the limited resources available and the large area over which British forces might have to operate, both the strike and the reconnaissance aircraft must be able to deploy rapidly over long distances. Aircraft might have to operate from airfields other than main bases and even though they might not be deployed in the most forward areas, they might have to stage through such airfields.

In a limited war, TSR.2's Reconnaissance role was primarily seen as providing tactical reconnaissance of airfields in support of the counter air battle and other targets in rear areas where because of the distances involved, the prevailing weather and tactical considerations, the use of other tactical aircraft or possibly drones was precluded..

However, the aircraft might also be required to obtain information in the battlefield area such as the location and details of targets suitable for attack and post-strike reconnaissance to enable the results of a strike to be assessed; enemy movement information to discover trends of movement which might indicate enemy plans; information on friendly forces such as the progress of operations and the effects of enemy attacks and topographical information about vital features such as bridges, roads etc, especially under adverse weather conditions.

The altitude at which these operations would be carried out would depend upon the effectiveness of the enemy's air defences, but the stronger the defences, the more operations would be carried out at low altitude.

Reconnaissance TSR.2s and Policing Operations

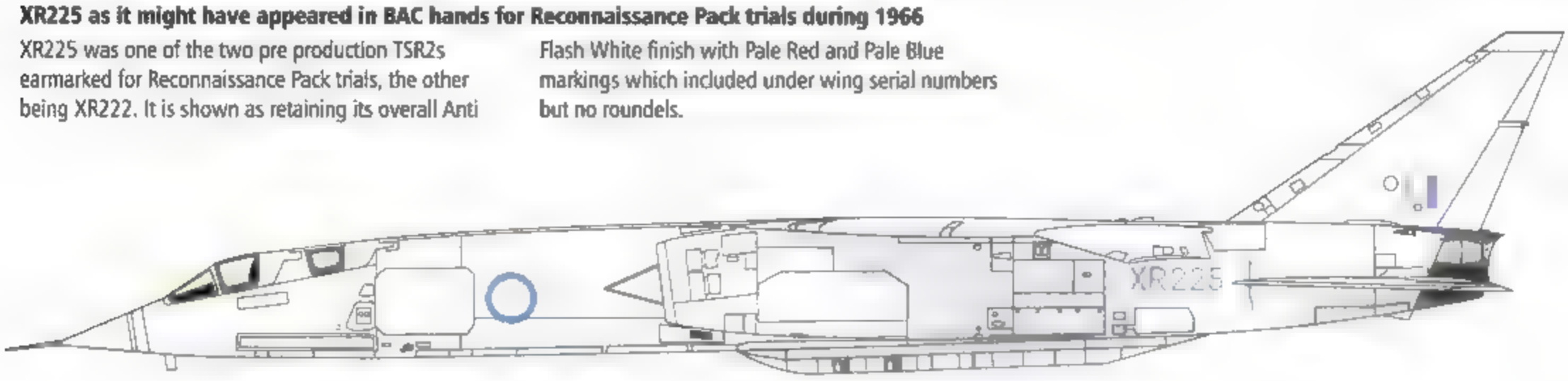
In minor policing operations specific information was often required of movements of small parties of men and of small and detailed man-made alterations to the topography of an area and TSR.2 could be used where there was such a need. Whilst it was recognised that some of these tasks would be inappropriate for TSR.2, it might be the only aircraft available for the job.

Intelligence requirements

Irrespective of whether a nuclear or conventional war was being fought, speed in gathering and dissemination of intelligence to the appropriate authority so that appropriate action could then be taken was seen as a prime consideration in reconnaissance operations. It was felt that the importance of reducing the time between the gathering of intelligence and its dissemination to

XR225 as it might have appeared in BAC hands for Reconnaissance Pack trials during 1966

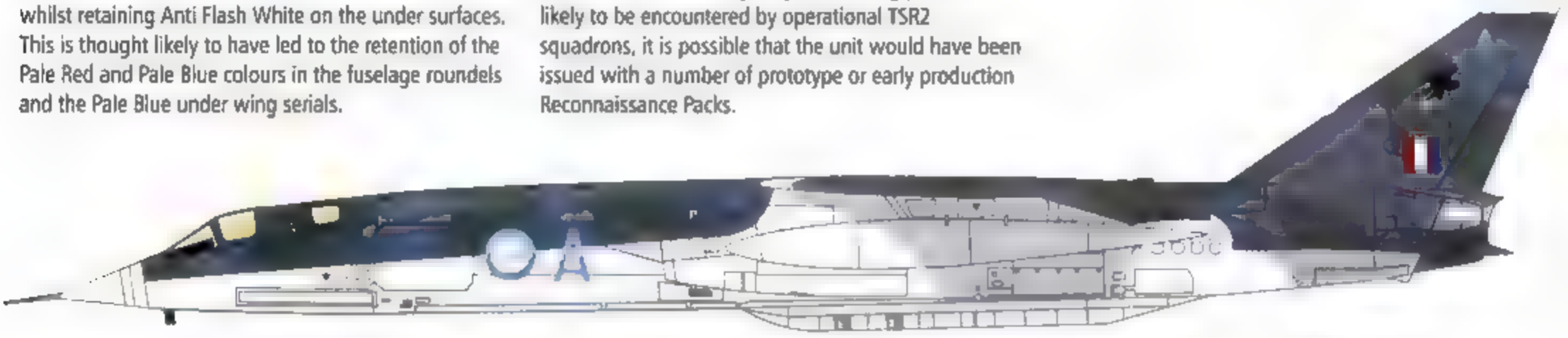
XR225 was one of the two pre production TSR2s earmarked for Reconnaissance Pack trials, the other being XR222. It is shown as retaining its overall Anti Flash White finish with Pale Red and Pale Blue markings which included under wing serial numbers but no roundels.



XS666 coded 'A' of the Operational Development Squadron of the Tactical Strike Establishment at Coningsby as it might have appeared during 1968

XS666 was one of the pre production batch which might have received the preliminary BAC Scheme of Dark Green and Dark Sea Grey on the upper surfaces whilst retaining Anti Flash White on the under surfaces. This is thought likely to have led to the retention of the Pale Red and Pale Blue colours in the fuselage roundels and the Pale Blue under wing serials.

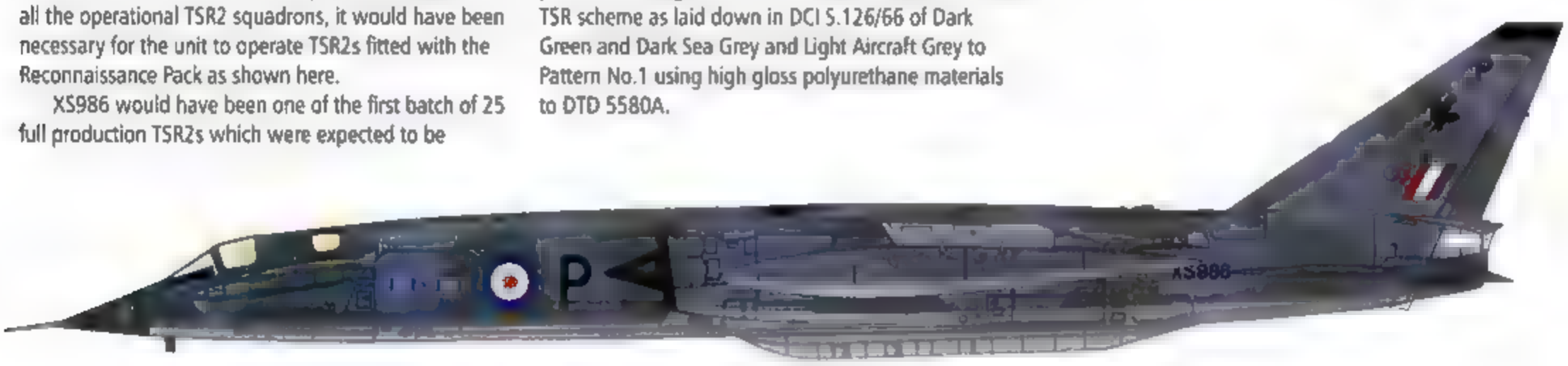
As the job of the ODS was to train the instructor crews for 237 OCU whilst establishing operating procedures and investigating and solving problems likely to be encountered by operational TSR2 squadrons, it is possible that the unit would have been issued with a number of prototype or early production Reconnaissance Packs.



XS986 coded 'P' of 237 OCU as it might have appeared in 1969

As 237 OCU was to be tasked to produce aircrews for all the operational TSR2 squadrons, it would have been necessary for the unit to operate TSR2s fitted with the Reconnaissance Pack as shown here.

XS986 would have been one of the first batch of 25 full production TSR2s which were expected to be produced during 1969 and is therefore illustrated in the TSR scheme as laid down in DCI S.126/66 of Dark Green and Dark Sea Grey and Light Aircraft Grey to Pattern No.1 using high gloss polyurethane materials to DTD 5580A.

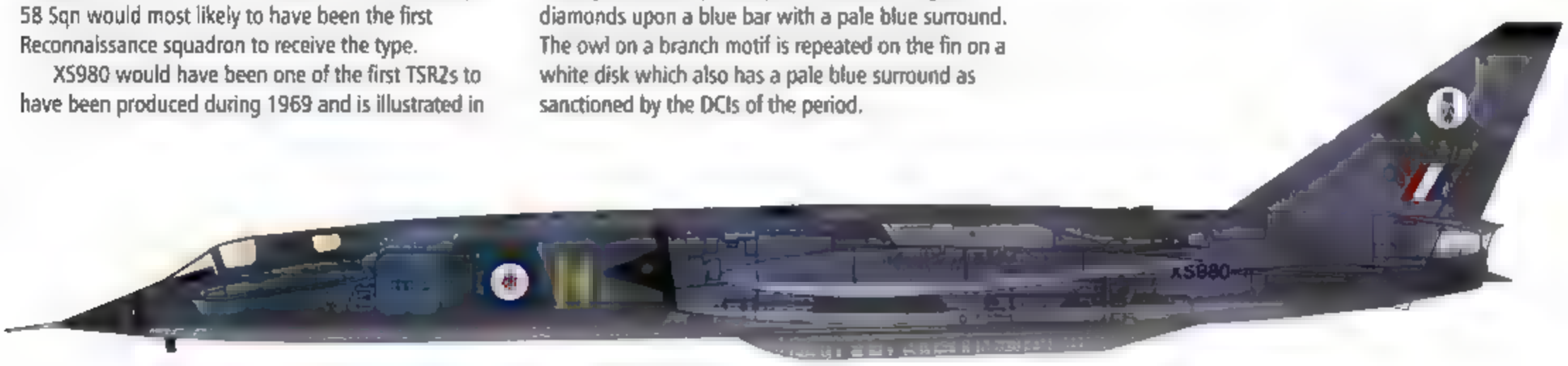


XS980 coded 'H' of 58 Sqn as it might have appeared in 1969

58 Sqn is known to have been earmarked as a TSR2 Reconnaissance squadron by an Air Ministry policy document in 1962. Once the decision had been made by the Air Ministry to accept the findings of the Spotswood report and to not base TSR2 in Germany, 58 Sqn would most likely to have been the first Reconnaissance squadron to receive the type.

XS980 would have been one of the first TSR2s to have been produced during 1969 and is illustrated in [illegible] Sqn markings which have been derived from those applied to the squadrons real world Hunters in 1973. These consist of the squadron badge of an owl on a branch inside a standard frame on the forward fuselage flanked by the squadron colours of green diamonds upon a blue bar with a pale blue surround. The owl on a branch motif is repeated on the fin on a white disk which also has a pale blue surround as sanctioned by the DCIs of the period.

Yellow has been selected as the colour of the code letter because 58 Sqn used yellow numerals to identify its individual Hunters.



interested authorities could not be overemphasised.

Information gathered by Linesman would be transmitted in flight which would provide the user with intelligence more rapidly than the other systems which would first require the aircraft to recover to an airfield with processing and interpretation facilities. However, facilities would be required for the processing and interpretation of Linescan film at the recovery airfields in case the in-flight transmissions failed to get through for any reason.

The basic Reconnaissance fit

It was accepted that strike and high-grade reconnaissance would not be combined in a single sortie. It was felt however that every opportunity must be taken at all times to obtain reconnaissance information and the aircraft would therefore be required to carry out the maximum photographic and or radar reconnaissance without prejudicing the Strike role.

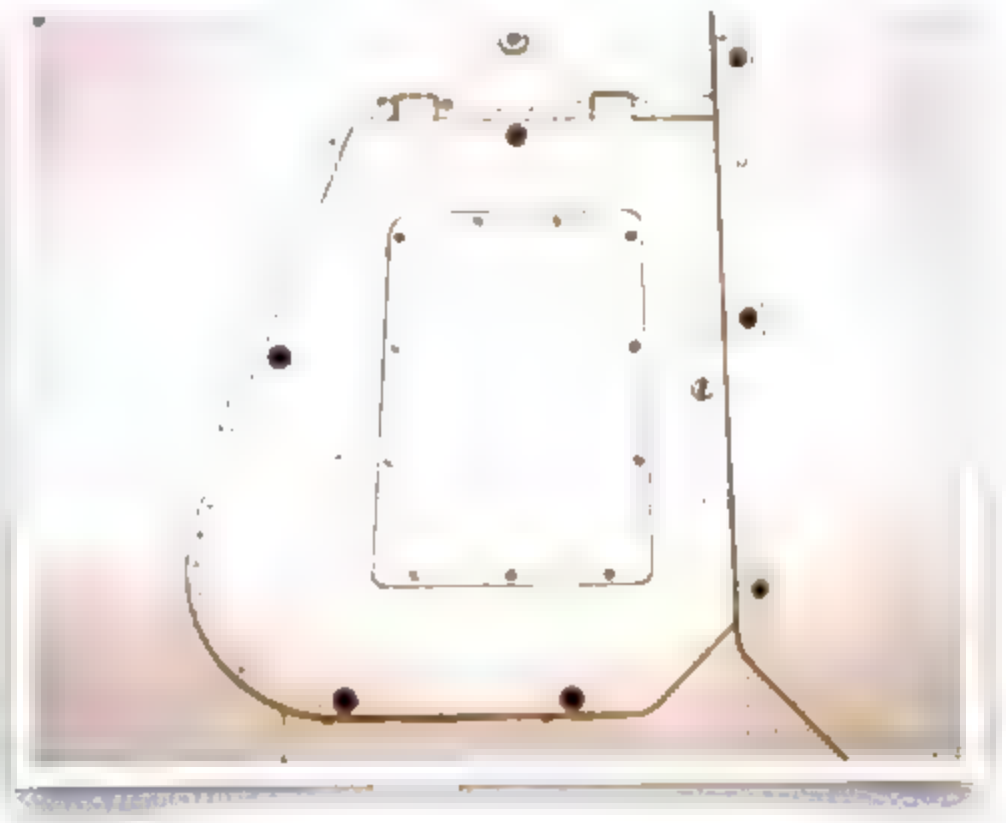
To meet this requirement, all TSR.2s, those operating in the Strike role as well as in the Reconnaissance role, were to be fitted with three RAF F.95 Mk.7 oblique cameras, one of which faced port, one starboard and one forward. These cameras were all fixed at an angle of depression of 15 degrees with the lens having an angle of view of 31 degrees. The ground coverage therefore extended from 27 yards from the aircraft outwards to the horizon at an altitude of 50ft and from 566 yards to the horizon at 1,000ft.

The cameras had 3 inch f1.8 lens and a taking speed of either 6 frames per second or 12 frames per second. Shutter speeds were 1/1,500 second at 6 frames/sec and 1/3,000 seconds at 12 frames/sec. Image movement compensation was included with two settings linked to the taking speeds. Exposure control was automatic continuously variable focal aperture.

The film magazines held 100ft of film which was sufficient for 40 seconds of continuous operation at 12 frames per second. Whilst an Operational Requirement existed for in flight processing which it was thought might reduce the magazine capacity by up to 75 percent, which would give only 10 seconds continuous operation, the conventional and in-flight processing magazines would be interchangeable.

As far as ground resolution was concerned, the greatest single limiting factor would be image movement which would vary with height and speed. Under the worst possible conditions imposed by a speed of 600 knots at 50ft a minimum resolution of 1ft was expected to be achieved. The cameras were expected to be effective from 50ft to 5,000ft but only in daylight conditions.

Location of the oblique cameras forward of the equipment bay

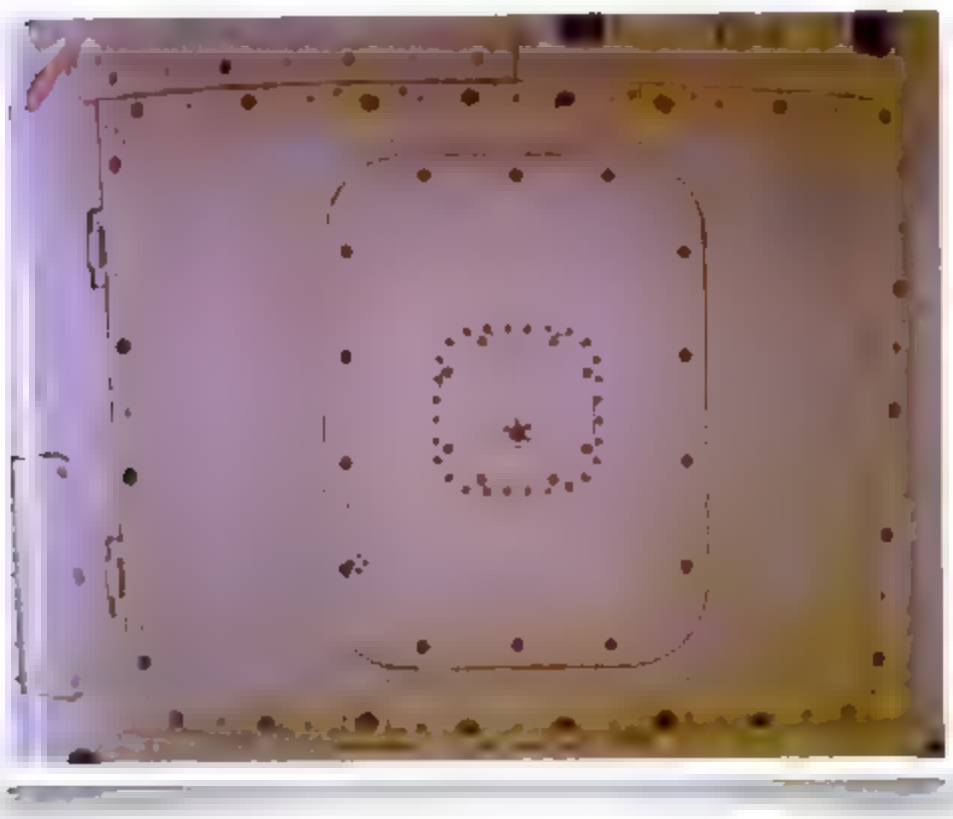


Close up of the oblique camera location

In TSR.2s which were fully converted to the reconnaissance role by carrying the reconnaissance pack, the latitude and longitude would be recorded onto each frame of the film with the necessary data being fed to the cameras from the pack. On the strike aircraft which were not fitted with the pack, this would not be the case.

Operating in the strike role the TSR.2 would therefore be capable of limited photographic reconnaissance and could be used on low-level reconnaissance tasks either during a strike sortie to obtain post-strike intelligence on the target attacked, pre-strike intelligence of targets en route or, during limited war operations, to augment the reconnaissance effort.

As stated above, originally, two of these cameras were to be oblique whilst one was to be retractable and forward facing. An RAE report of November 1962 is however thought to have criticised the forward-facing camera arrangement on the grounds that the pilot would have only 0.1 second to recognise and react to a target one and a half miles ahead of the aircraft. As a consequence, in April 1963 the Directorate of Operational Requirements decided that TSR.2 would have a F. 95 Mk.7 with a one and a half inch wide high-angle lens looking vertically downwards fitted in place of the retractable forward facing camera.



Close up of the vertical camera location. The front of the aircraft lies at the bottom of the photo

Specialist Reconnaissance Pack

The necessary equipment to convert the TSR.2 to the Tactical Reconnaissance role was enclosed within a single Reconnaissance Pack which was fitted into the weapons bay under the fuselage. The Reconnaissance Pack was divided into two compartments, the forward one containing the radar elements which consisted of the SLRR with its Photographic Recorder and the Linescan, the

XV909 coded 'W' of 17 Sqn as it might have appeared in 1970

XV909 was one of the TSR2s expected to be produced during 1970. It has therefore been illustrated in the TSR scheme as laid down in DCI S.136/69 of Dark Green and Dark Sea Grey on the upper surfaces and Light Aircraft Grey under surfaces to Pattern No.1. All these colours would probably have been high gloss polyurethane to DTD 5580A.

The shock cones and intake lips have been shown as being coloured black as it has been suggested that the shock cone and intake lip of production aircraft would have been electrically heated. An alternative explanation might be that these areas might have been treated with a special finish to reduce the radar cross section of the aircraft as mentioned in Chapter 8.

Whilst it is known that two of the three Canberra squadrons based in RAF Germany were expected to re equip with TSR2s, it is not known which two these would be. Following the decision made to not base any TSR2s in Germany in the aftermath of the Spotswood report, it is thought likely that the RAFs most senior Canberra Reconnaissance squadrons would have been the most likely units to have received the type.

The second most senior of the Canberra Reconnaissance squadrons based in Germany during the mid 1960s was 17 Sqn and it is therefore suggested that this squadron would also have received TSR2 in the Reconnaissance role.

rear which was sealed to prevent contamination by atomic particles, containing the Photographic Cameras and the Airborne Radio Link and Data Unit. All of these items of equipment could be used in the low-level role but only the SLRR with its Photographic Recorder and the Photographic Cameras would be used in the medium-level role.

SLRR and Photographic Recorder

The SLRR was manufactured by EMI and employed 15ft long sideways-looking aerials which transmitted in the Q-band of the electromagnetic spectrum. The beams were fan shaped in the vertical plane, scanning the terrain on either side of the aircraft by virtue of the aircraft's forward movement, and the signals could be directed either from both sides of the aircraft at once or from one side only.

The returning signals were photographically recorded on a film in the Photographic Recorder, a moving film camera, where they were annotated with data from the navigation computer which would be required for subsequent interpretation.

Recording was in two forms, Mapping, which was a pictorial presentation of the terrain covered, and Moving Target Indication (MTI) which depicted only moving targets and which could only be used at low level.

Mapping

Forward cover was limited only by the 25ft length of the film which was carried in the recording instrument. This was sufficient for 1,500nm cover at a scale of 5nm per inch of film or 3,000nm at a scale of 10nm per inch.

Lateral cover depended upon the altitude of the aircraft and the angle at which the aerials were set. The aerials could be set at five different angles ranging from 10 degrees above the horizon to 20 degrees below. The aerials were to be set horizontally at low altitudes and at increasing angles of depression as the operating height was increased.

The radar had a 5, 10, and 20-mile timebase with the lateral coverage varying between 866 to 28,580ft in the five-mile case and 28,020 to 82,040ft in the 20-mile case. This left a gap in cover immediately below the aircraft which would vary between 1,732ft (2 times 866ft) and 56,040ft.

The mapping display would reveal such geographical features as rivers, coastlines, hills and woodlands, and well defined topographical features such as roads, bridges, buildings etc.

MTI

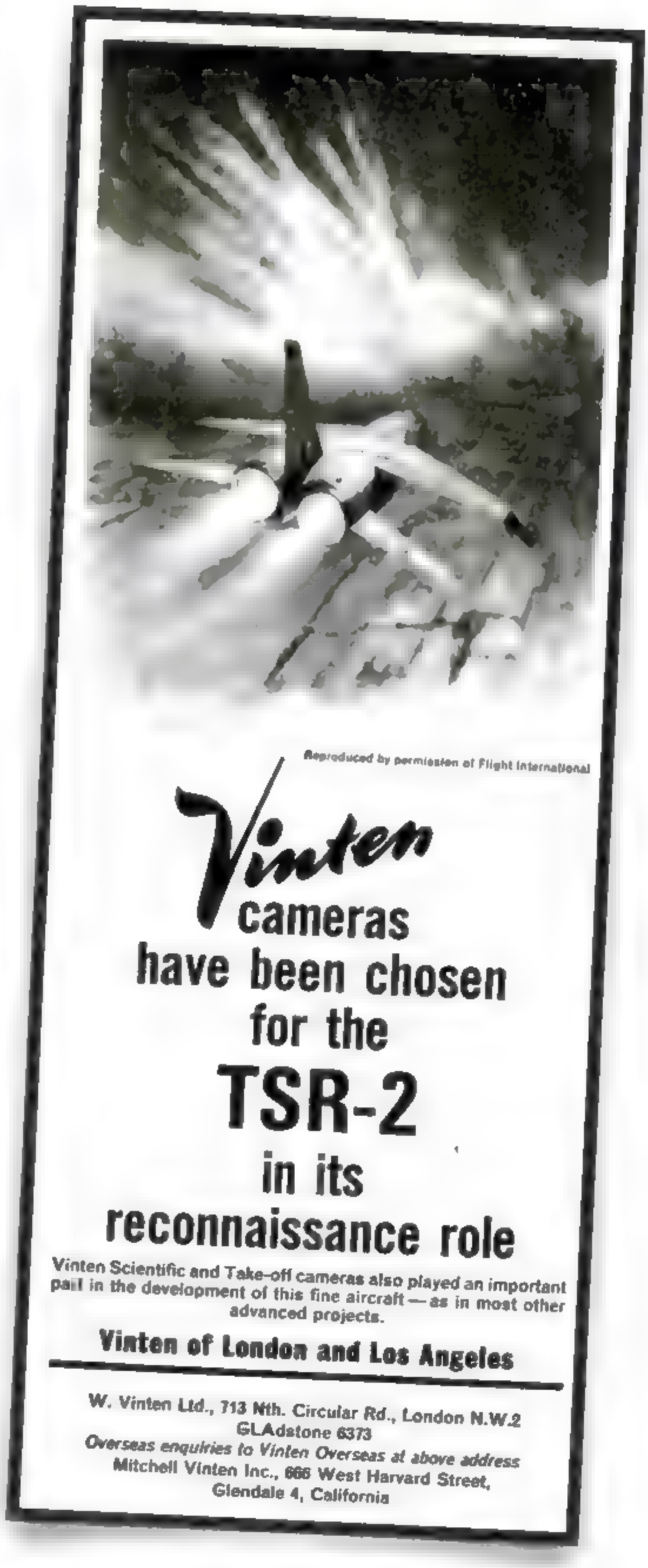
The MTI record would depict moving objects as small dots or streaks on a plain background and it was necessary to relate the MTI record to its associated Mapping record in order to determine the position of any particular object.

The MTI system would not normally detect objects moving parallel to the flight line of the aircraft.. The component of motion detected was to be that at right angles to the flight path and a relative speed in this direction of at least three and a half miles an hour was necessary. The system would not enable moving objects to be identified by type with the possible exception of a railway train.

Data recording

The following data was to be recorded on the central strip of the film:

a) Aircraft attitude in pitch
b) Aircraft heading
c) Aircraft altitude
d) Latitude and Longitude at quarter mile intervals.

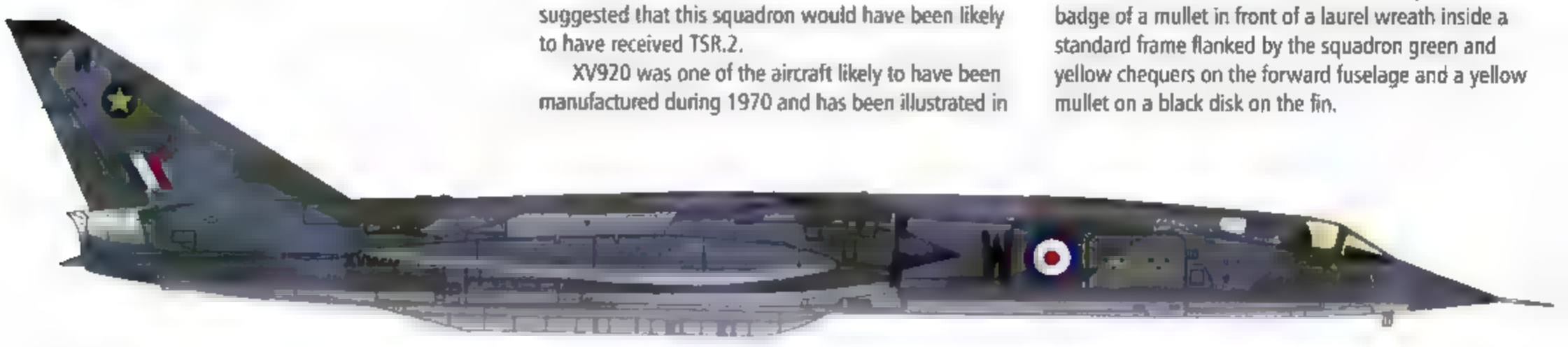


Contemporary Vinten advert for its cameras which were to be used in TSR.2

XV920 coded 'W' of 31 Sqn as it might have appeared in 1970

Whilst it is known that two of the three Canberra squadrons based in RAF Germany were expected to re equip with TSR.2s, it is not known which two these would be. Following the decision made to not base any TSR.2s in Germany in the aftermath of the Spotswood report, it is thought likely that the RAFs most senior Canberra Reconnaissance squadrons would have been the most likely units to have received the type. 31 Sqn was the most senior of the three Canberra Reconnaissance squadrons based in Germany during the mid 1960s and it is therefore suggested that this squadron would have been likely to have received TSR.2.

XV920 was one of the aircraft likely to have been manufactured during 1970 and has been illustrated in the standard TSR scheme of Dark Green and Dark Sea Grey on the upper surfaces and Light Aircraft Grey on the under surfaces, including the Reconnaissance Pack. The squadron markings illustrated are based upon those carried by the squadrons real world Phantom FGR.2s from 1971. These consist of the squadron badge of a mullet in front of a laurel wreath inside a standard frame flanked by the squadron green and yellow chequers on the forward fuselage and a yellow mullet on a black disk on the fin.

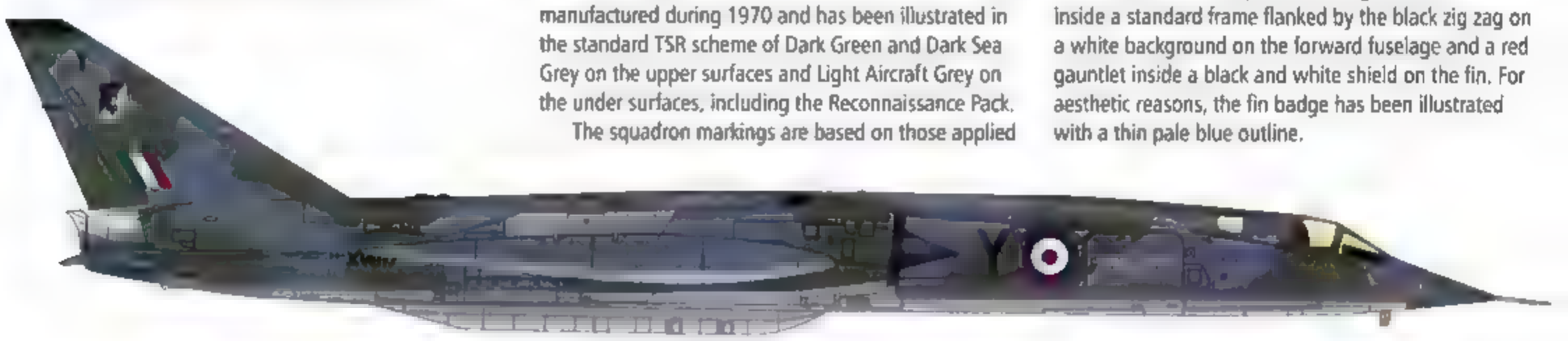


XV917 coded 'Y' of 17 Sqn as it might have appeared in 1971

The second most senior of the Canberra Reconnaissance squadrons based in Germany during the mid 1960s was 17 Sqn and it is therefore suggested that this squadron would also have received TSR2 in the Reconnaissance role.

XV917 was one of the aircraft likely to have been manufactured during 1970 and has been illustrated in the standard TSR scheme of Dark Green and Dark Sea Grey on the upper surfaces and Light Aircraft Grey on the under surfaces, including the Reconnaissance Pack.

The squadron markings are based on those applied to a variety of aircraft types over the years, including the squadrons real world Phantom FGR2s of 1970. These consist of the squadrons red gauntlet motif inside a standard frame flanked by the black zig zag on a white background on the forward fuselage and a red gauntlet inside a black and white shield on the fin. For aesthetic reasons, the fin badge has been illustrated with a thin pale blue outline.

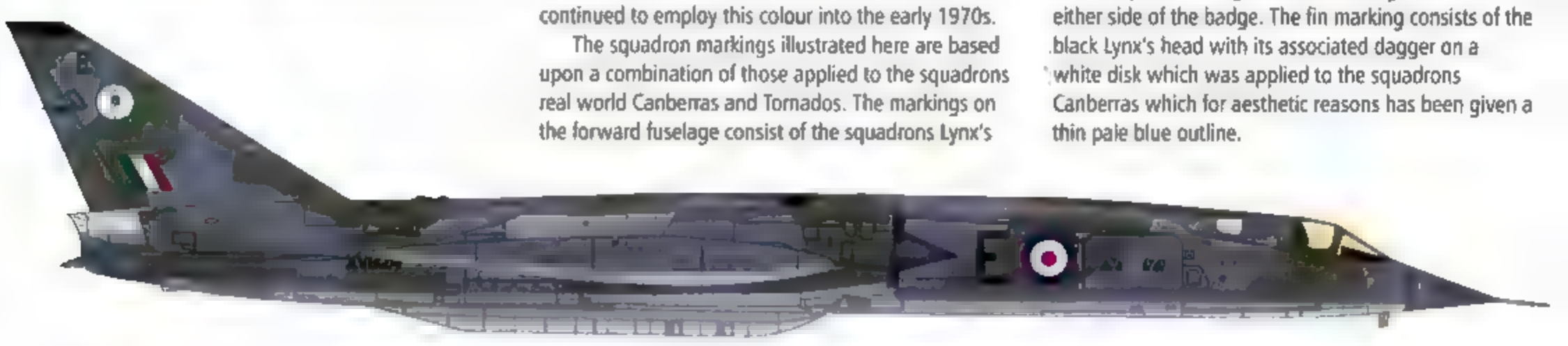


XV294 coded 'E' of 13 Sqn as it might have appeared in 1971

13 Sqn is known to have been earmarked as a TSR.2 Squadron by an Air Ministry policy document of 1962.

XV294 is illustrated with Dark Green and Dark Sea Grey on its upper surfaces whilst the under surfaces have been repainted in Medium Sea Grey under the provisions of DCI. S.126/66. Even though this option appears to have been withdrawn by DCI S.136/69 some reconnaissance Canberras are known to have continued to employ this colour into the early 1970s.

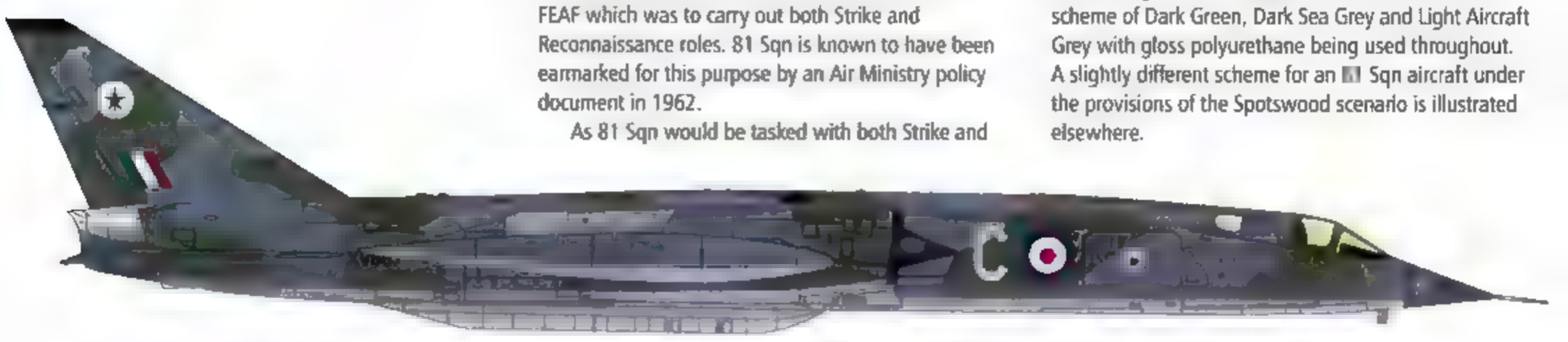
The squadron markings illustrated here are based upon a combination of those applied to the squadrons real world Canberras and Tornados. The markings on the forward fuselage consist of the squadrons Lynx's head and dagger motif inside a standard frame flanked by the squadron colours. The colours are taken from the Tornado and consist of a yellow gunners stripe which separates the green and blue segments of a bar either side of the badge. The fin marking consists of the black Lynx's head with its associated dagger on a white disk which was applied to the squadrons Canberras which for aesthetic reasons has been given a thin pale blue outline.



XV887 coded 'C' of 81 Sqn as it might have appeared in 1972 under the provisions of Plan 'P' of March 1964

Under the provisions of Plan 'P' it was intended to deploy a single TSR2 squadron of 10 aircraft UE to FEAF which was to carry out both Strike and Reconnaissance roles. 81 Sqn is known to have been earmarked for this purpose by an Air Ministry policy document in 1962.

As 81 Sqn would be tasked with both Strike and Reconnaissance roles, XV887 which would have been built during 1970 is illustrated in the Standard TSR scheme of Dark Green, Dark Sea Grey and Light Aircraft Grey with gloss polyurethane being used throughout. A slightly different scheme for an 81 Sqn aircraft under the provisions of the Spotswood scenario is illustrated elsewhere.



XV910 coded 'B' of 81 Sqn as it might have appeared in 1971 under the provisions of the Spotswood scenario

Under the provisions of the Spotswood report it is possible that FEAF might have had two TSR2 squadrons under its control, one for Strike and one for Reconnaissance in place of the single squadron which was to carry out both tasks under the provisions of Plan 'P'. The assumption which has therefore been made is that 81 Sqn would have been a dedicated Reconnaissance squadron in the Spotswood scenario and would therefore be able to take advantage of the option of finishing the under surfaces of its aircraft ■ Medium Sea Grey under local Command authority as provided for in DCI. 5.126/66.

XV910 has therefore been shown with all its under surfaces, including the Reconnaissance Pack and drop tanks finished ■ Medium Sea Grey whilst the upper surfaces retain the usual TSR colours of Dark Green and Dark Sea Grey with gloss polyurethane being used throughout.

XV944 coded 'G' of 58 Sqn as it might have appeared in 1972

Because 58 Sqns war role involved overland tactical reconnaissance operations over Scandinavia for Air Force North, it is suggested that the Squadrons TSR2s might have been on occasion the recipients of the 'arctic' camouflage shown here. Under the provisions of DCI S.70/72 All Weather Fighter, Fighter Ground Attack, Tactical Strike and Photographic Reconnaissance Aircraft could employ a matt white water based distemper to DTD 441 as part of their disruptive camouflage finish.

XV944 would have been one of the last TSR2s produced in 1971 and might therefore have been finished with the matt polyurethane finish and toned down markings shown here. Following the promulgation of the Red and Blue national markings to the service by DCI. S.70/72 there appears to have been some degree of confusion as to whether the new national markings should be used on under surfaces by the way in which the instructions were worded. As a result, many aircraft retained their traditional Red, White and Blue roundels under their wings for some time and this is how XV944 has been illustrated.

XV944 is shown with the White distemper applied over the Dark Sea Grey segments of its upper surface camouflage as photographic evidence indicates that Dark Green and White was the most frequently used combination though the DCIs stated that the White should be applied over the Dark Green segments of the camouflage. The Light Aircraft Grey under surfaces remained unaffected.

The SLRR therefore provided a means of obtaining and recording on photographic film high-definition radar maps of the terrain on both sides of the aircraft together with information relating to moving targets on the ground. The film had to be processed after landing with the intention being to get the intelligence thus acquired in the hands of field commanders within two hours of their making a request for information. It was hoped that later developments would allow in-flight processing and/or transmission.

Optical Linescan

The Optical Linescan was an optical scanning system based on a rotating prism which scanned the ground across the aircraft track. The image from the prism was focused by a lens onto a photoelectric cell where the brightness of the image was converted into an electronic signal.

The Linescan could be operated in one of two modes, passive mode during the day when it used the available daylight, and active mode at night when it used an onboard light source which provided a means of obtaining and storing pictorial information which could then be transmitted electronically to a ground station where a photographic record of the ground through an arc of 144 degrees along the aircraft track could be produced.

The scanner detected variations in brightness as it scanned the ground in line-by-line sweeps at right angles to the aircraft track by employing a rapidly spinning mirror to project the incident light onto a photoelectric cell. The photoelectric cell converted the variations in light intensity it received into an electrical signal which could then be collected on an airborne video recorder which could be removed after landing or transmitted to a ground based receiving station. Once downloaded from the aircraft by whatever means, the signals could be converted into monochrome prints which were annotated with the latitude, longitude and altitude of the aircraft.

For nocturnal use, the Linescan was to be used in active mode whereby a second rapidly rotating mirror was used to transmit a high intensity light synchronised with the receiving mirror which thus lit the ground below line-by-line as the scan was carried out. Movement of the light over the ground was so rapid as to be undetectable to normal vision and thus did not betray the position of the aircraft, unlike the more conventional photo flash required by the conventional cameras carried by other reconnaissance aircraft of the period such as the RF-4 Phantom. The information thus obtained was similar to that which could be obtained from aerial photography but its resolution was limited by engineering and physical considerations. The order of resolution stipulated in the operational requirement for the Linescan was to be sufficient for the identification of a three-ton truck

The rotating mirrors viewed the ground through two sets of windows, the first in the scanner itself, the second in the skin of the Reconnaissance Pack. The latter were to be shuttered when the Linescan was not in use. The requirements for these windows were severe as under operational conditions they could not be allowed to introduce any appreciable aberrations in the images obtained or cause undue loss of light. The form of window aperture considered most practical had three flat glass plates mounted in a suitable framework. The glazing bars between the plates served a double purpose in that besides supporting the plates, they also acted as light baffles to prevent ghost images and other undesirable effects due to light being reflected into the scanner from the glass surfaces.

Because Linescan information could be transmitted over a radio link the information could be received at a ground station whilst the reconnaissance was still in progress and there was no need to wait for the aircraft to return to base (if indeed it did return to base) before the production on the ground of a picture suitable for interpretation. Transmission was limited to line-of-sight range and at 200ft this was of the order of 25 miles. To transmit from greater distances which could be up to 120 miles the aircraft would have to climb, and the extent to which this would be possible would depend upon operational circumstances.

The facility for in-flight transmission was one of the two major advantages that Linescan had over the other sensors carried by TSR.2, the other being its night use which gave better resolution than was provided by radar. Its one drawback was that it could be affected by adverse weather in the same way and to approximately the same extent as conventional cameras in that it could not see through cloud and/or smoke and it was therefore not an all-weather sensor.

Cameras

It was originally intended that a new aerial camera, the FX.126 would be developed to Operational Requirement 8024 for use in TSR.2's Reconnaissance Pack. As this was delayed, it was instead firstly agreed that the F. 95 Mk.2 would be accepted as an interim fit but by April 1963 it had been accepted that the F.95 Mk.7 would meet both OR 8024's and TSR.2's timescale.

Three cameras were to be fitted in the rear compartment of the Reconnaissance Pack, one fitted with lens of 36 inch focal length, one with 24 inch focal length and one with 6 inch focal length, which would produce photos at the interpretation scale of 1/10,000 when used at operating heights of 30,000ft, 20,000ft and 10,000ft respectively, which would be good enough to classify types of ships, buildings and other large structures. When used from lower altitudes the interpretation scales would be much larger allowing classification of individual vehicles. The production of high definition photographs was aided by means of image movement compensation and auto exposure allowing frames to be taken at supersonic speeds and an altitude of 1,250ft.

Film capacity was to be 250ft of film which was sufficient for 320 exposures, each of which would have the latitude and longitude recorded on them from signals received from the aircraft navigation system.

Strategic Reconnaissance?

The question as to whether TSR.2 would also be capable of Strategic Reconnaissance and Survey work appears to have arisen in December 1963 when the Director of Air Plans offered the opinion that TSR.2 could be given a survey capability "without much difficulty". This view was rebutted by the Deputy Director of Operations (Reconnaissance) in a loose minute dated 16 December 1963 when he stated that whilst it was true that a

Victor SR.2s of 543 Sqn provided the RAF with its Strategic Photographic Reconnaissance and Survey capability

survey installation could be devised for TSR.2 it would not be sufficient to merely exchange one of the reconnaissance cameras in the Reconnaissance Pack with a survey instrument. Not only were the survey cameras of different size and shape, they were also twice as heavy as the nearest equivalent reconnaissance cameras and they would require an entirely different type of mounting and control system. This would entail an extensive modification of the camera control system within the aircraft and almost certainly the development of a separate survey pod, all of which would undoubtedly entail considerable expense. It is not known whether anything was ever done to develop a separate Survey Pack for TSR.2.

Reconnaissance Pack production

On 27 June 1962 a meeting was held at Weybridge to discuss the reconnaissance system programme where it was decided that four prototype Reconnaissance Packs were to be made up. One was to be used for testing, one was to be fitted to the fourth aircraft, one to the seventh aircraft whilst the remaining pack would be a spare. All the pre-production TSR.2s from the third aircraft onwards would be capable of carrying the Reconnaissance Pack but the time needed to carry out the job would depend on the particular instrumentation fit of that aircraft.

On full production aircraft, the role change from Strike to Reconnaissance role was effected by the installation of the Reconnaissance Pack in the weapons bay and the replacement of the Bombing Control Panel in the navigator's cockpit by two other panels which carried the controls for the SLRR, Linescan and the Photographic Cameras.

By March 1964 it would appear that 33 Reconnaissance Packs were on order. This figure appears to have been arrived at by provisioning for seventy-five percent of the front line TSR.2 Reconnaissance force as given in Plan 'P' of 36 aircraft. This gave a figure of 27 packs with 4 packs in reserve and just 2 packs being allocated to training and other contingencies.

Whilst at least one prototype Reconnaissance Pack was completed prior to TSR.2's cancellation in April 1965 it is not known how representative this was of the final production version which was expected to be ready for service by the last quarter of 1968, thereby allowing what is described in the documents dealing with this matter as "the Canberra Reconnaissance squadron in Bomber Command" to begin to re-equip during early 1969.

It is not known what, if any, arrangements were made to allocate Reconnaissance Packs to either the Operational Development Squadron or 237 OCU of the Tactical Strike Establishment but as it is known that the ODS would not be likely to form before June 1967 at the earliest, it would appear that the in-service dates of both the TSR.2 and its Reconnaissance Pack were converging and availability of the Reconnaissance Packs may not have been a problem.

Canberra PR.9s were by this time being increasingly seen as Tactical Reconnaissance aircraft and were one of the aircraft types that TSR.2 was expected to replace

ELINT

Comparatively little is known of TSR.2's ELectronic INTeligence gathering capability. It was initially proposed that TSR.2's ELINT equipment should be fitted as an overload pod in the Reconnaissance role so that ELINT information on enemy Command, Control, Communications and Information (3CI) systems could be obtained along with other reconnaissance information as outlined above. It would appear that this electronic intelligence gathering facility would be used in conjunction with the TSR.2's Radar Illumination Warning System which is discussed in more detail in the next chapter. The information thus gathered could be put to a variety of uses such as working out an optimum flight plan for strike aircraft which took account of the position and type of enemy radar whilst also influencing decisions on the carriage of Window, decoys or jammers whilst other information could be passed to interested parties. It would appear that a draft Naval Air Staff Target was in the process of being prepared for what is described as a Passive ECM Tactical Aid (PETA) for tactical aircraft by the time that TSR.2 was cancelled.

TSR.2 Reconnaissance squadrons

In 1962 a policy document was prepared which outlined the RAF's current Photographic Reconnaissance squadrons and equipment along with their proposed futures. At that time Bomber Command had two Reconnaissance squadrons at its disposal. The first of these was 543 Sqn which was equipped with Valiant B(PR)K.1s which were operated in the in the Radar, Strategic Photographic Reconnaissance and Survey roles. These were expected to remain in service until 1966 when they would be replaced in the same role by Victor SR.2s. The second Reconnaissance squadron was 58 Sqn which at that time was equipped with a mix of Canberra PR.7s and PR.9s which were tasked with low-level tactical reconnaissance by day and night and whose war role included overland reconnaissance of Scandinavia for Air Force North. 58 Sqn was earmarked for TSR.2s which were expected to enter service in 1968.

RAF Germany had three Canberra reconnaissance squadrons. These were 17, 31 and 80 Sqns of which two were expected to be re-equipped with TSR.2s from 1967. Unfortunately, the document does not make it clear which two of these three squadrons were to receive TSR.2. If the same rationale of seniority is applied to these Reconnaissance squadrons as to the Strike squadrons discussed previously, the two most senior squadrons are 31 Sqn and 17 Sqn.

Near East Air Force had two Canberra squadrons, 13 Sqn equipped with Canberra PR.9s and 39 Sqn equipped with Canberra PR.3s. Of these 13 Sqn was expected to equip with TSR.2s whilst 39 Sqn was expected to equip with either Canberra PR.7s or PR.9s in 1967. In the event 39 Sqn received the Canberra PR.9 which it continued to operate until May 1983.

Far East Air Force had only one squadron, 81 Sqn, which was equipped with Canberra PR.7s. These were expected to be replaced by TSR.2s from 1968.

This planned squadron pattern appears to have survived until it was incorporated into Plan 'P' in March 1964 which stated that Bomber Command would have one Reconnaissance TSR.2 squadron with 8 UE, RAF Germany would have two Reconnaissance TSR.2 squadrons of 8 UE, Near East Air Force would have one Reconnaissance TSR.2 squadron of 8 UE whilst Far East Air Force would have one TSR.2 squadron which would be of 10 UE but which would be tasked with both Strike and Reconnaissance roles. Of these 10 aircraft, it would appear that 4 would be earmarked for the Reconnaissance role. Thus there would have been

XV935 coded 'D' of 13 Sqn as it might have appeared in 1972/73

XV935 would have been one of the last batch of TSR2s produced during 1971 which might have had the toned down national markings and a matt polyurethane finish. It has therefore been illustrated with a full set of toned down national markings and the opportunity has been taken to illustrate a change in 13 Sqns markings which seems to have been made on their real life Canberras at about the same time as the toned down markings and matt finish were introduced.

The squadron badge which was applied to the fins of its Canberras were originally applied to a White disk as allowed for in the DCI's of the period. When the toned down national markings and the matt finish was introduced however, the colour of the disk on the fin was changed from White to Red, presumably as part of the toning down procedure. XV935 has therefore been illustrated with the Lynx's head and dagger motif applied to a Red disk in place of the White disk shown on XV294 'E' illustrated elsewhere.

Note that whilst XV935 has been illustrated with Medium Sea Grey under surfaces, the Reconnaissance Pack and Drop tanks retain their original Light Aircraft Grey finish as these items were interchangeable between aircraft.

XV937 as it might have appeared at Red Flag 9/77 in September 1977

Had TSR.2 been sent to Nellis AFB in Nevada to participate in Red Flag 9/77 there is the possibility that some of the participating aircraft would have been recamouflaged for the occasion in a similar manner to the Buccaneers which were sent in reality.

A camouflage scheme thought to be more appropriate to operations at low altitude over desert terrain was applied allegedly with distemper materials to DTD 441 in using the same colours as employed by the RAF's Tactical Transport Aircraft, BS 381C No. 450 Dark Earth and BS 381C No. 361 Light Stone. On the upper surfaces the Dark Earth was applied over the areas of camouflage which were normally Dark Green and the Light Stone was applied over the areas which were normally Dark Sea Grey. In addition to this, the Dark Earth and Light Stone camouflage was also extended (or 'wrapped around) onto the under surfaces in a similar manner to the wrap round schemes employed on the Jaguar, Harrier and TWU Hawks.

In the process of applying the new temporary camouflage, all trace of the squadron markings were covered up, though the serial numbers and many of the safety and warning markings remained visible.

a total of four dedicated TSR.2 Reconnaissance squadrons and one mixed Strike and Reconnaissance squadron.

On the basis of the evidence provided by the 1962 Reconnaissance force policy document it is therefore suggested that the TSR.2 Reconnaissance squadrons in order of seniority would have been 13 Sqn, 58 Sqn, 31 Sqn, 17 Sqn and 81 Sqn.

Squadron Pattern and the Spotswood scenario

As discussed in Chapter 1, Plan 'P' was modified by the Spotswood Report which concluded that the TSR.2 force required was 63 aircraft based in the UK assigned to SACEUR; 20 aircraft in NEAF and declared to CENTO though the individual squadrons would deploy on a rotational basis from the UK; 20 aircraft in FEAF also deployed on a rotational basis from the UK, and a UK based strategic reserve of 20 aircraft of which 8 would be earmarked for NATO thus giving a front line total of 123 aircraft.

If this force of 123 aircraft is split up into squadrons using a standard UE of 12 aircraft per Strike squadron and 8 aircraft per Reconnaissance Squadron, then the UK based force assigned to SACEUR of 63 aircraft would essentially make up 4 Strike Squadrons of 12 aircraft plus two Reconnaissance squadrons of 8 aircraft (which actually gives a total of 64 aircraft). The 20 aircraft in NEAF, FEAF and the UK based strategic reserve would consist of 1 Strike squadron with 12 aircraft and 1 Reconnaissance squadron with 8 aircraft. This gives a total of 7 Strike Squadrons and 5 Reconnaissance Squadrons.

The apparent requirement for 5 Reconnaissance squadrons would therefore appear to increase the number of front line Reconnaissance TSR.2s from 36 to 40 on account of a dedicated Reconnaissance squadron of 8 UE taking the place of the 4 Reconnaissance aircraft of the mixed squadron in FEAF.

There is some question however as to whether these 5 squadrons would have been dedicated Reconnaissance squadrons in the traditional sense since the Spotswood Report does not appear to distinguish between Strike and Reconnaissance TSR.2s. It might therefore be the case that all the TSR.2 squadrons were expected to operate a number of reconnaissance aircraft. This however would appear to be unlikely from a practical point of view and in the author's opinion it is more likely that a number of squadrons would have had to specialise in the reconnaissance role.

The only change that the Spotswood Report was likely to have made to the TSR.2 squadron pattern therefore is that 81 Sqn might have become a dedicated Reconnaissance squadron with ■ UE instead of a mixed Strike and Reconnaissance squadron of 10 UE.

Reconnaissance camouflage and markings 1966–72

Defence Council Instructions (DCIs) dealing with the camouflage and marking of TSR aircraft, DCI S. 126/66, DCI S. 136/69 and DCI S. 70/72 have all been discussed previously describing the gloss polyurethane Dark Green BS 381C No.641 and Dark Sea Grey BS 381C No.638 upper surface and Light Aircraft Grey BS 381C No.627 under surface camouflage with Post Office Red BS 381C No.538 White and Roundel Blue BS 381C No.110 national markings and Black serial numbers which were to be applied to TSR aircraft.

DCI S.126/66 allowed some leeway in the painting of the under surfaces of Reconnaissance aircraft however. After stating that the under surfaces of TSR aircraft were to be Light Aircraft Grey, DCI S.126/66 went on to state that "For reconnaissance aircraft, Medium Sea Grey may be used at the discretion of commands." It is known that a number of Canberras were finished with Medium Sea Grey under surfaces but exactly how widespread this practice was in which Command is unknown.

When DCI S.126/66 was replaced by DCI S. 136/69 this statement was dropped. A number of reconnaissance Canberras however are known to have retained their Medium Sea Grey under surfaces until 1972 if not later.

Following TSR.2s cancellation, the Canberra PR.9 soldiered on receiving a tactical camouflage finish from the early 1970's

One further camouflage development occurred with the issue of DCI S.70/72 in April 1972 which is of particular relevance to 58 Sqn's role in relation to overland reconnaissance in Scandinavia. In a note appended to the section dealing with the camouflage of All Weather Fighter, Fighter Ground Attack, Tactical Strike and Photographic Reconnaissance Aircraft it is stated that "For Arctic Operations the Dark Sea Green areas may be overpainted with a matt white water-based distemper to Specification DTD 441, on the authority of the AOCinC". This appears to have included a typographical error as 'dark sea green' should presumably have read 'dark sea grey'. However all subsequent DCIs and GAIs up to 1977 (the most recent documents of this type seen by the author) continue to state that it is the Dark Green which is to be overpainted by white for Arctic operations whilst photographic evidence almost always shows that it was the Dark Sea Grey segments of the camouflage which were overpainted in white.

TSR.2 camouflage and markings 1972–1980

At the time of writing, hard information from Primary sources on the camouflage and marking of RAF aircraft runs out with GAI 1002 dated January 1977 at which time All Weather Fighter (excluding Lightning) Tactical Strike (excluding Jaguar), Tactical Reconnaissance and aircraft of Light Bomber origin were to be coloured in a matt finish as follows:

- All upper surfaces, fuselage sides, fin and rudder were to bear a disruptive camouflage pattern of Dark Sea Grey BS 381C No.638 and Dark Green BS 381C No.641.
- Lower surfaces of the fuselage, mainplanes and tailplanes were to be coloured Light Aircraft Grey BS 381C No.627.
- National markings were to be applied to the upper and lower surface of each mainplane, each side of the fuselage and each side of the fin. These were to consist of roundels and fin flashes coloured Post Office Red BS 381C No.538 and Roundel Blue BS 381C No.110 applied in a matt finish.
- Aircraft serial numbers and identification letters were to be Black although it was stated that identification letters could be enhanced during normal peacetime operations.
- ECM Pods on Buccaneer aircraft were to be painted (not including the radome) Dark Green BS 381C No.641 over the area which was visible from above forward of the wing leading edge from the top to 2 inches below the horizontal centreline on each side of the pod.

'Wrap around'

Whilst the introduction of the 'wrap around' camouflage scheme on tactical aircraft such as the Jaguar and Harrier appears to have been first promulgated by DCI S.68/75, by the issue of GAI

One of No 208 Squadrons Buccaneers painted in the Dark Earth/Light Stone 'wraparound' scheme for the 'Red Flag 77-9' exercise in the USA

1002 in January 1977, this scheme had only spread as far as the Hawks of the TWUs. Thus it would appear that by early 1977 the TSR.2 would still have been finished in the Dark Sea Grey, Dark Green and Light Aircraft Grey scheme outlined above.

It is possible however that the practice of finishing TSR.2s in the Dark Sea Grey, Dark Green and Light Aircraft Grey scheme might have begun to come to an end as a result of the RAF participation in Red Flag 77-9 which took place at Nellis Air Force base during August 1977.

Red Flag

One of the key lessons which the USAF and USN drew from the Vietnam War was that until aircrews had become experienced in combat operations they showed a low level of operational effectiveness whilst enduring unacceptably high loss rates, with the first ten missions being judged to be the key to a crew's survival in war. Following the end of the Vietnam War, the USAF's solution to this problem was to establish the Red Flag organisation at Nellis AFB whose mission was to create in peacetime an environment which was as close as possible to that envisaged in a future war.

The original plan was to deploy every USAF Tactical Air Command squadron to Red Flag for at least one month-long exercise in every 18 months and thus give their crews the critical initial ten missions under wartime conditions in comparative safety. The idea was a success and as the great training value and operational realism of the Red Flag scenarios became known, participation was expanded to allow deployments by units from all the other branches of the US armed forces. In 1977 an invitation was extended to RAF Strike Command to become the first foreign participants in a Red Flag exercise, and a small force of Vulcans and Buccaneers was dispatched to take part.

A novel camouflage scheme

The ten Buccaneers dispatched to Nellis for Red Flag were all drawn from 206 Sqn, eight of which retained their normal Dark Sea Grey, Dark Green and Light Aircraft Grey colour scheme. Four Buccaneers, XV160, XV352, XX900 and XX901 however were partly repainted, allegedly with distemper materials to DTD 441 in a camouflage scheme thought to be more appropriate to operations at low altitude over desert terrain using the same colours as employed by the RAF's Tactical Transport Aircraft, BS 381C No.450 Dark Earth and BS 381C No.361 Light Stone.

On the upper surfaces the Dark Earth was applied over the areas of camouflage which were normally Dark Green and the Light Stone over the normally Dark Sea Grey areas. In addition, the Dark Earth and Light Stone camouflage was also extended onto the under surfaces in a similar manner to the wrap around schemes employed on the Jaguar, Harrier and TWU Hawks, this being thought to be the first time such a scheme was applied to the Buccaneer.

The only part of the airframe not recamouflaged in Dark Earth and Light Stone was the rear fuselage aft of the engine exhausts, presumably on account of the hot gasses which issued from the jetpipes, this demarcation also being a feature of Buccaneers which were given a temporary 'Arctic' camouflage whereby White was applied over the Dark Sea Grey segments of the camouflage as discussed previously. The slipper and ventral fuel tanks were also recamouflaged though the ALQ 101 ECM Pods retained their normal Dark Green and Light Aircraft Grey finish as described above.

By the time of their return from Nellis both XV160 and XV352 sported a red star forward of the roundel and a small plan view silhouette of a Vulcan on the port side of the fuselage. Though the new camouflage finish was supposed to be easily removable it has been claimed that the temperatures at Nellis were so high that upon return to the UK it was found that the finish had been baked and proved to be very difficult to remove, with both aircraft still retaining their desert camouflage for at least a month after their return.

One of the lessons which it is thought that the RAF took from its first Red Flag deployment was that like the Jaguar, Harrier and TWU Hawks, the Buccaneer would benefit from the elimination of the Light Aircraft Grey under surfaces which tended to give the aircraft away when being manoeuvred at low level. As a result of this, during 1978 the Dark Green and Dark Sea Grey wrap around scheme began to be applied to the Buccaneer fleet so that it was common to most Buccaneers by 1979.

Red Flag TSR.2s

In a world where the Vulcan had been phased out and the Buccaneer had never entered service with the RAF it is possible that the only aircraft type to have been sent to Nellis by the RAF to take part in Red Flag 77-9 would have been the TSR.2. There is therefore a case to be argued for a number of these aircraft being camouflaged for this purpose in a wrap around scheme of Dark Earth and Light Stone.

Subsequently, it would probably be reasonable to assume that the 'Wrap around' scheme of Dark Sea Grey and Dark Green would have been adopted for the TSR.2 fleet from 1978 and would have remained in use until TSR.2's retirement or the advent of the Camouflage Grey schemes, whichever came sooner.

Though principally intended to advertise the rocket pods, this Buccaneer S.2 can be seen to be also carrying 1,000lb Type N.1 bombs under the outer pylons

XV947 coded 'T' of 9 Sqn as it might have appeared in the 'Wrap Round' Scheme circa 1980

One of the lessons which it is thought that the RAF took from its first Red Flag deployment was that like the Jaguar, Harrier and TWU Hawks, the Buccaneer would benefit from the elimination of the Light Aircraft Grey under surfaces which tended to give the aircraft away when being manoeuvred at low level. As a result of this, during 1978 the Dark Green and Dark Sea Grey wrap round scheme began to be applied to the Buccaneer fleet so that it was common to most Buccaneers by 1979. It would therefore probably be reasonable to assume that the 'Wrap Round' scheme of Dark Sea Grey and Dark Green would have been adopted for the TSR.2 fleet from 1978 and would have remained in use until TSR.2's retirement or the advent of the Camouflage Grey schemes, whichever came sooner.

XV947 would have been one of the last batch of TSR2s produced during 1971 which might have had the toned down national markings and a matt polyurethane finish applied on the production line. Given that the expected life span of a polyurethane finish was between 5 and 7 years XV947 might have been due for a repaint circa 1978 and thus have been one of the first TSR2s to receive the 'Wrap Round' camouflage scheme as shown here.

The camouflage pattern shown on the under surfaces of XV947 is the mirror image of the pattern applied to the upper surfaces and in order to illustrate this clearly, the aircraft has been illustrated 'clean' without underwing stores.

Chapter 8

Countermeasures

WHEN OR 343 WAS BEING PREPARED IN 1959 THE SPECIFICATION stated that the aircraft would carry such electronic countermeasures as may be dictated by the nature of the opposing weapon systems in the Theatre concerned. These countermeasures could not be precisely specified until the feasibility of future developments had been assessed, but it was stated that at the very least a passive warning receiver system was required which was to provide visual and aural warning of attack from any direction and to be capable of triggering any of the countermeasures carried by the aircraft.

The countermeasures which were expected to be developed as part of TSR.2's ECM programme which were to be allowed for in the design of the aircraft were listed as follows:

a) Between 6 and 12 rocket propelled radar and infra-red decoys which would fly forwards and upwards from the aircraft
b) 24 cartridges of explosively launched very rapidly blooming Window
c) One of a series of noise jammers or a deception jammer designed to confuse specific radar systems whose aerial system should as far as possible have 360 degree coverage around the aircraft and might be composed of several interchangeable units.

When the countermeasures to be employed by TSR.2 first began to be considered in 1959 the Air Ministry Electronic Warfare Committee set up a Subcommittee on ECM for the TSR.2. Because the TSR.2 was expected to serve from 1965 to 1980 the Committee realised that they had to be very far-seeing and attempt to ensure that the provisions they recommended would be adequate even in what they saw as the very distant future.

In the absence of any positive intelligence information on the type of low-level defensive systems which the Soviet Union might be able to field during this period, the subcommittee equated the appropriate current and projected electronic and missile development in the UK and USA to that which the Soviets might also be able to achieve.

On this basis the subcommittee concluded that during the in-service life of TSR.2 it might be possible for an enemy to deploy an effective defence against it based chiefly on mobile and/or fixed Continuous Wave (CW) Surface-to-Air Guided Weapon systems for point defence, similar to the British Bloodhound and US HAWK systems, which could be expected to be located adjacent to the prospective target supported by a High Frequency early warning system. Low-level fighter defence was considered to be a lesser threat though it was acknowledged that if a long range tracking system directing fighters with clutter-free radar and homing weapons was to be deployed this might not remain the case.

The prospects for the survival of TSR.2 in the face of such defences would be improved if maximum use could be made of its low-flying capability under conditions of radio silence, especially in the high frequency band, and further enhanced by the use of suitable ECM devices. These devices could take many forms and taking a lead from the those outlined in the specification as given above, the following countermeasures were considered for possible use on TSR.2:

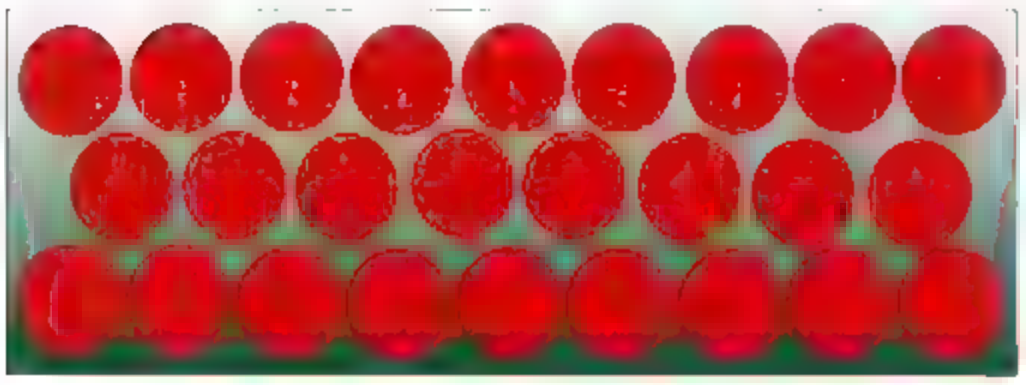
a) The application of absorbent materials to reduce to ■ practicable minimum the Radar Cross Section (RCS) and infra red signature, what today would be termed 'Stealth technology'
b) Radar decoys for use against tracking and homing radars
c) Explosively launched Rapid Blooming Window
d) A passive warning system which, by giving warning of illumination or 'lock on' by radar, would allow the efficient use of countermeasures or the implementation of suitable tactics to further delay detection of the aircraft
e) Electronic jamming devices
f) Infra red decoys.

The subcommittee on ECM for the TSR.2's final report made the following recommendations. First, it recommended that the aircraft to OR 343 be designed in such a way as to reduce to a practicable minimum the infra-red signature and Radar Cross Section (RCS). This was to be accomplished in part at least by the application of Radar Absorbent Materials (RAM).

Second, the aircraft was to be fitted with a passive warning system which, by giving warning of illumination or 'lock on' by radar, would allow the efficient use of countermeasures or the implementation of suitable tactics to further delay detection of the aircraft.

Third, the aircraft was to have provision for carriage of suitable radar decoys for use against tracking and homing radars.

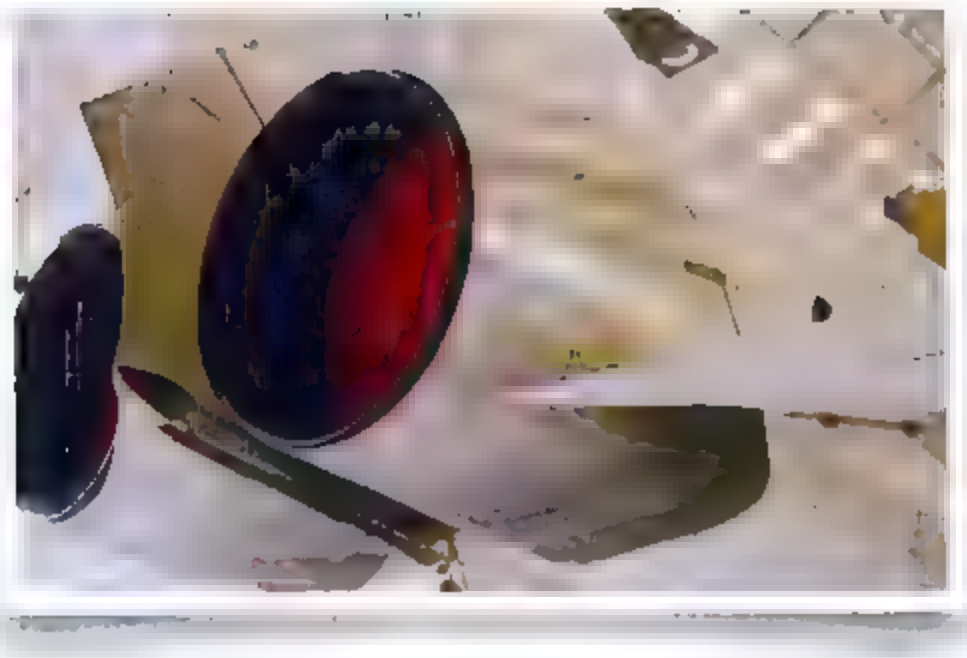
Fourth, provision was to be made for explosively launched Rapid Blooming Window to confuse enemy radar.



Rapidly Blooming Window Matrice

■ was decided that TSR.2 would have a Rapidly Blooming Window installation which would be capable of unlocking a radar during medium or high level flight and jamming a radar during the target approach run in the Nuclear Strike role. Several suggestions were made as to how the specified 90-100 RBW cartridges should be carried following the decision that the only type of dispenser suitable for TSR.2 would be a fixed honeycomb matrix similar to the one illustrated here. The type of matrix illustrated here with a capacity of 26 cartridges was eventually adopted for use on the Canberra T.17 where three such matrices were enclosed within specially modified wingtip tanks. Of the three matrices, one pointed downwards at 90 degrees to the line of flight whilst the other two pointed inboard and outboard at 45 degrees to the line of flight.

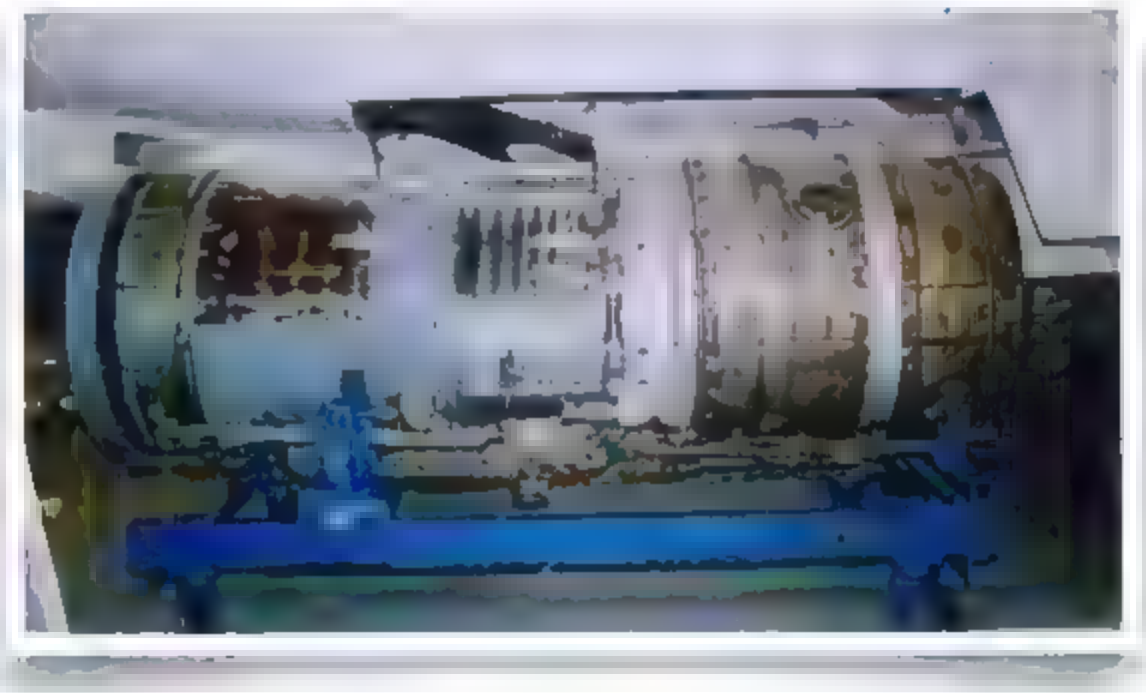
As the original drawings of the RBW installations for TSR.2 do not appear to have survived, the following illustrations have been based on the surviving written descriptions and on the 26 cartridge honeycomb matrix design shown here which is known to have existed and been used on real aircraft for exactly this purpose. It is tempting to speculate that the RBW matrix used by the Canberra T.17 was originally designed for TSR.2.



In a bid to reduce the IR signature of the engines, they were buried deep within TSR.2s fuselage

The 'hot' back end of the engine

Close up of the afterburner



The front end of the engine with cut away clear panels which allow the multitude of compressor blades to be seen

Fifth, the aircraft was to have provision for the carriage when required of ECM equipment. This was to be installed in such a way as to confer flexibility whilst presenting the minimum operational penalties. The subcommittee suggested that the aircraft should have wing pylons, or other fitments to enable the ECM stores to be hung on the outside of the main airframe. This would allow not only the development and fitment of new ECM systems as time went on, but also the tactical flexibility to alter the ECM fit to suit the prevailing circumstances at any given time. Provision was also to be made for adequate electric power for future ECM purposes.

Finally, it was also recommended that a further study be undertaken of possible ECM tactics for the OR 343 aircraft including the use of ECM support aircraft both of OR 343 and other types.

Infra red signature

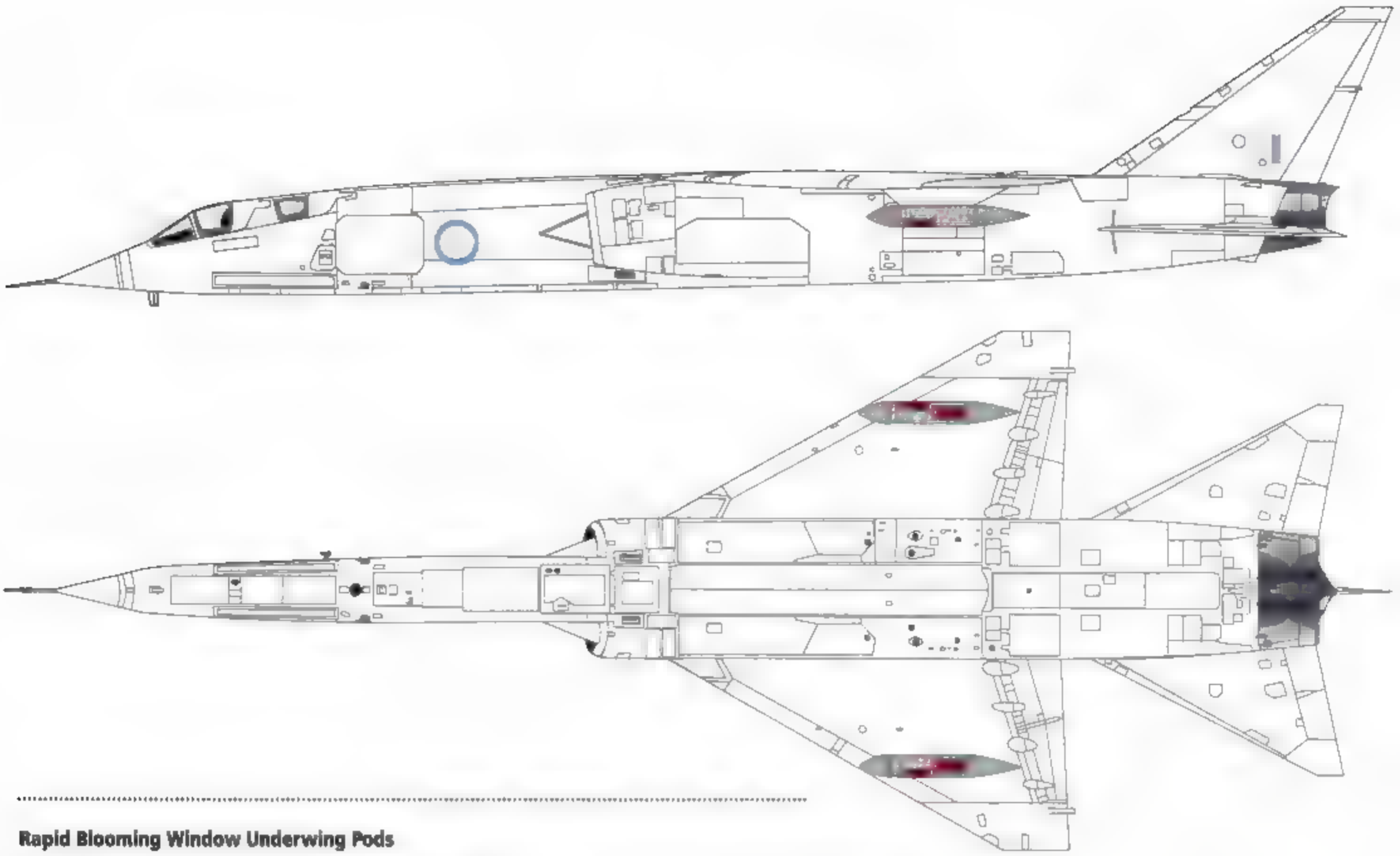
RAE Technical Memorandum Rad 551 of July 1960 'Screening of IR Radiation from an Aircraft' discussed various ways by which the IR signature of an aircraft could be obscured. It focused in the main on the use of sheet metal screens and smoke screens, concluding that metal screens attached to the aircraft were likely to give screening only in certain directions and that the resulting penalty in weight and drag would probably be prohibitive. TSR.2 benefited to some extent from this type of screening by having its jetpipes buried deep within the fuselage and thus avoiding hot protruding tailpipes.

As far as smoke screens were concerned, experiments had shown that it might be possible to screen a V-Bomber for 10 seconds with 200lb of carbon and whilst fundamental theory indicated that better smokes were possible, there were no grounds at that time for thinking that such smokes could be made. It was therefore concluded that having hidden the IR source within the aircraft to the greatest degree possible, an IR decoy flare, launched when an IR homing missile had been fired, would be a suitable countermeasure which could draw the weapon away from the aircraft.

Infra-Red Flares

The flares were designed to fulfil an Air Ministry Operational Requirement, OR 3605, which called for the development of a decoy flare to protect V-Bombers against Infra-Red guided weapons at high altitudes of approximately 40,000 ft. By March 1963 IR Flare type E/2/1 had been chosen as the Mk. 1 decoy. The flares themselves were two and a quarter inches diameter and five point three inches in length. When the V-Bombers adopted the low-level role in 1964 their operating conditions changed and this necessitated a

IR Flare and or Rapidly Blooming Window (more commonly known today as 'Chaff') dispensers 'scabbed' onto the under surface of a Tornado F.3



Rapid Blooming Window Underwing Pods

The first proposal as to how the RBW could be carried was that the cartridges be mounted in pods under the outboard weapons pylons in a manner similar to that shown here. About 50 RBW cartridges were to be carried which are shown here being mounted in two matrices per pod, one of which fires downwards whilst the other fires outboard at 45 degrees.

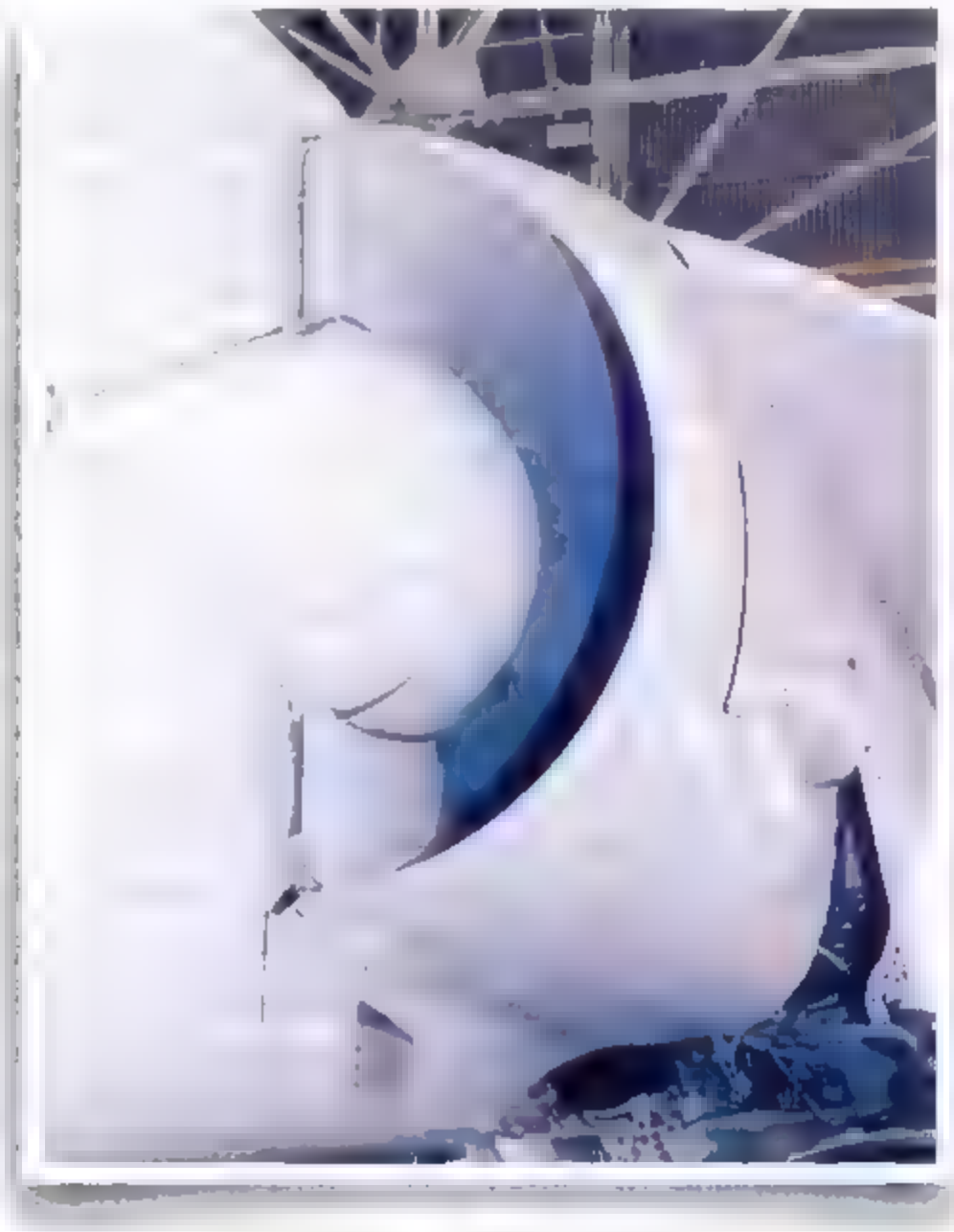
new series of trials of the IR flares at low and medium level which showed the flares to be satisfactory. It is thought that this type of flare could have been selected for use by TSR.2 as besides their satisfactory performance at medium and low levels, their physical dimensions were identical to the explosively launched Rapidly Blooming Window (RBW) cartridges which were being developed for use by TSR.2 and it would therefore be possible to deploy them from the same type of matrix as the RBW.

Stealth technology

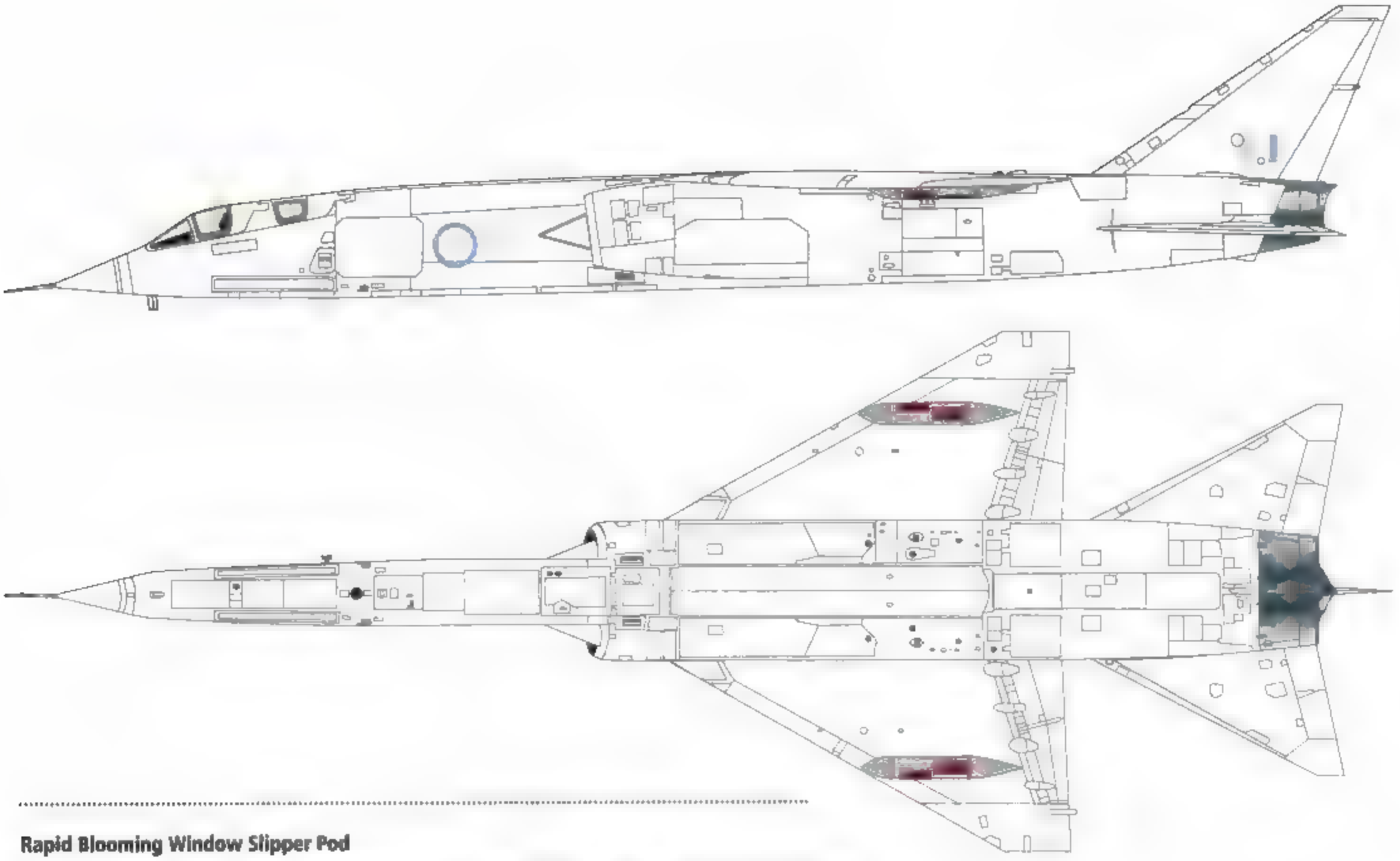
By the early 1960s the RAF had been experimenting with so called 'Radar Camouflage' for several years and a number of different materials and techniques were available and being developed to absorb or deflect radar energy. It was thought that these might be applied with advantage to critical parts of the structure which would give a maximum reduction in the Radar Cross Section (RCS) of about 50 percent thus reducing radar detection range by 20 percent. The Air Ministry was of the opinion that all possible steps should be taken to reduce the RCS at X-band and all higher frequencies and any reduction at C-band would be highly desirable whilst reduction at S-band would be desirable but not worth any additional penalty in weight or complexity.

Special attention was paid to the head-on aspect as it was intended that the enemy should not see TSR.2 coming and three of the most important reflecting areas were defined as being the Air Intakes, the Forward Looking Radar and Bulkhead and the Cockpit. Broadside and rear aspect RCS reduction were apparently not considered to be important.

Measurements of TSR.2's RCS revealed that within an arc of plus or minus 50 degrees of the nose cone, the radar echoing area could be assessed as being approximately 20 square metres of which over half was due to the air intakes. The intake region gave the largest reflections whilst at the same time posing the greatest difficulties to the available materials due to temperature and distortion problems. It



The intakes were found to be responsible for over half TSR.2's head on RCS. It was therefore suggested that the intake cone and first two or three feet of the intake wall would benefit from being coated with a RAM, but at that time the existing materials were considered unsuitable



Rapid Blooming Window Slipper Pod

The second proposal was a slipper arrangement could be used which would offer a weight saving over the underwing pod whilst also reducing the range penalty of the installation. Again about 50 RBW cartridges were to be carried which are shown here being mounted in two matrices per pod, one of which fires downwards whilst the other fires outboard at 45 degrees.

transpired that the intake cone and the first two or three feet of the intake wall required covering with RAM but the available material(s) could not withstand the high temperatures and the consequent structural distortions in the critical intake area. No parts of the radar camouflage material could be allowed to detach under any circumstances due to the risk of its ingestion to the engines and therefore the idea of using RAM in this area was abandoned in March 1960.

It was noted however that the problem of providing radar camouflage for intakes would keep recurring with other aircraft and it was suggested that a project contract be let for a high-temperature high-strength material which would be absorbent on specified wavebands. It was also suggested that this material should be specified as being applicable to TSR.2 during its service life.

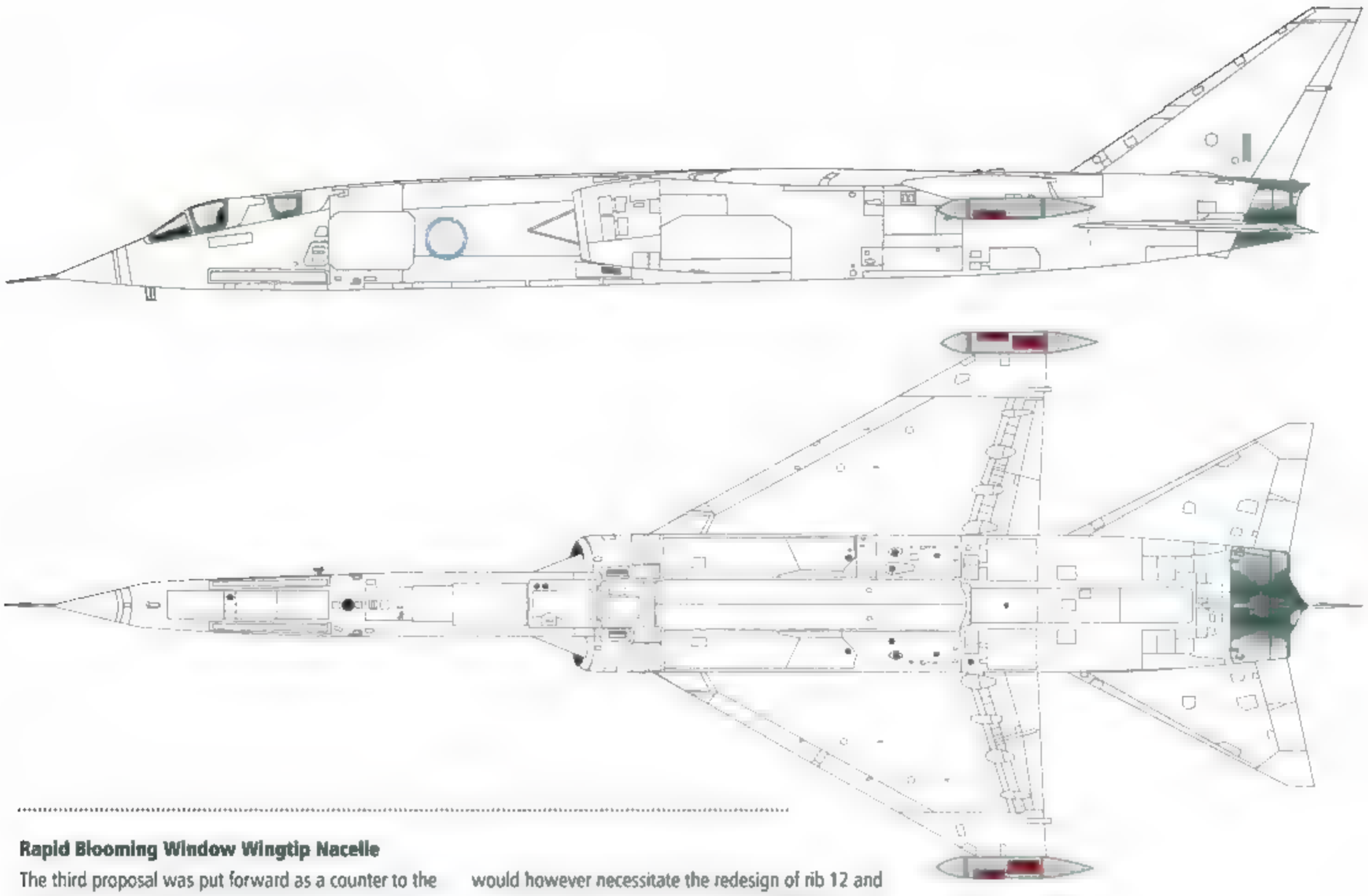
Exactly what action was taken with regard to these suggestions is not clear, but by early 1963 Vickers Armstrongs thought that they might have a solution to the problem of camouflaging the intakes in the form of a very thin metallic film which was to be applied in the form of a copper oxide paint mixed with some form of resin. On 14 February 1963 Vickers Armstrongs wrote to the Ministry of Aviation informing them of the new idea in order to check that their understanding of the problems associated with the application of the existing materials was still valid and the requirement for this kind of countermeasure still existed. At the same time they pointed out that any activity relating to the new idea beyond a preliminary evaluation would need to be paid for by additional funding. Vickers Armstrongs requested instructions in this matter. Unfortunately, what happened next is currently unknown.

A number of suggestions were put forward as to how the nose bulkhead and the Forward Looking Radar dish might be camouflaged. The problem with this was that for such measures to be successful, the radar would have to be inoperative and as the use of the radar was of critical importance to TSR.2's terrain-following capability, which was regarded as a countermeasure in its own right, it was decided that the radar was more valuable in operation even at the expense of its providing a large echoing area.

Cockpit camouflage

A brief, non-mathematical introduction to the state of the art of radar camouflage for aircraft as it was in September 1959 was summarised in RAE Technical Note No. Rad 765 dated January 1960. In the section which dealt with radar camouflage for cockpits the report discussed methods of camouflaging cockpit interiors. Under normal circumstances radar waves penetrated the cockpit canopy and bounced off the pilot and nearby equipment before returning to the receiver. In order to camouflage the cockpit it was therefore necessary to make the canopy opaque to radar waves whilst remaining transparent to light. Two alternative methods of accomplishing this on operational aircraft were then described. The first involved having a double-wall canopy which was filled with a liquid such as alcohol or water which was electronically lossy. The second alternative, which was considered to probably be the more simple method,

The gold film which provided radar camouflage for the cockpit interior is seen to advantage in this view of XR220's canopy



Rapid Blooming Window Wingtip Nacelle

The third proposal was put forward as a counter to the reduction in the under wing stores carrying capability which was inherent in the use of either the underwing pods or slippers. The adoption of the wing tip nacelles would however necessitate the redesign of rib 12 and the tip of each wing as well as additional wiring runs. The RBW matrices are again shown as firing downwards and outboard at an angle of 45 degrees.

The gold film allowed an electric current to flow which warmed the canopy and aided demisting

was to coat the inside of the canopy with a gold film and this appears to have been the option which was applied to TSR.2, as the metallised glass would satisfy the requirements for good vision, resistance to bird strikes, a low expansion coefficient and demisting.

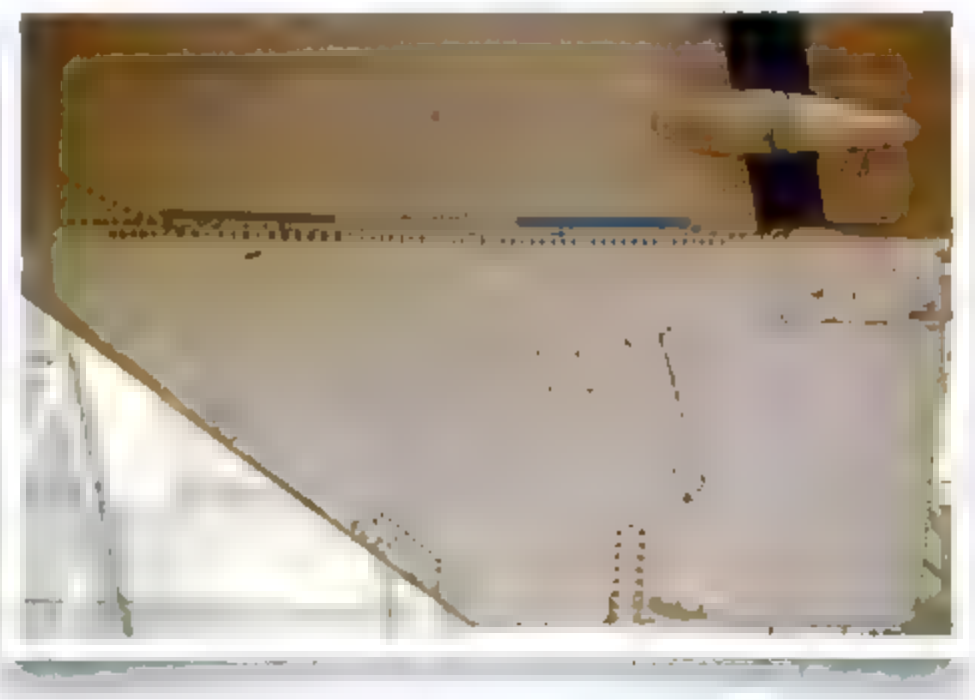
The Radar Illumination Warning System

Paragraph 65 of OR 343 set out the requirements of the Radar Illumination Warning System (RIWS). It stated that at least a passive warning receiver was required which was to provide visual and aural warning of attack from any direction. The aural warning was originally intended to be designed in such a way as to enable the operator to recognise the typical pattern of track-while-scan radar but ultimately this requirement was dropped and only the standard warning tone was to be used instead.

X-band coverage was considered to be essential both in Pulse and Continuous Wave whilst J-band was considered to be desirable and Q-band possibly worth having. There was no requirement to cover S-band and lower frequencies. It was noted that a knowledge of the direction, range and exact type of transmission might provide useful intelligence information and that consideration should be given to the carriage of suitable equipment in the Reconnaissance role as mentioned previously.

Competitive study contracts for the RIWS were placed with Marconi and Ferranti in August 1960 and their study reports had been received by the Air Ministry in November 1960. By the end of December 1960 there was a firm recommendation on technical grounds that the production contract should be placed with Ferranti.

By July 1962 it had become clear that though it should be possible to obtain some cover in the Q-band a considerable amount of



Various aerials were set into the TSR.2s skin

work would be necessary and it was argued that in any foreseeable defensive system an indication would be available in one of the other bands covered by the receiver, and the Air Staff agreed that work on the Q-band should cease.

The RIWS was also intended to be capable of automatically triggering of any of the countermeasures that the aircraft was carrying at the time and as a consequence it was necessary that the false-alarm rate should be very low. Initially, it was agreed that Ferranti should aim at a system which relied on a confirmation time of not more than five seconds and did not give more than one false alarm in 1,000 hours of operation.

Other development problems were arising with the aerial layout on the airframe. Originally conceived as a two-station system with the aerials built into the skin of the aircraft, it was found that this two-station system did not give a satisfactory degree of all-round coverage with there being a significant gap in coverage to the rear of the aircraft. It was therefore agreed that a four-station system should be developed instead. Even so, the development of a suitable aerial system which gave all-round coverage seems to have caused major problems for some considerable time.

It is thought that development of this complex RIWS was actually completed following TSR.2's cancellation, possibly in anticipation of using it in conjunction with the F-111. However when this too was cancelled it is thought that the system was found to be too big to fit aircraft types such as the Buccaneer, Harrier and Jaguar. What became of it is currently unknown.

PETA

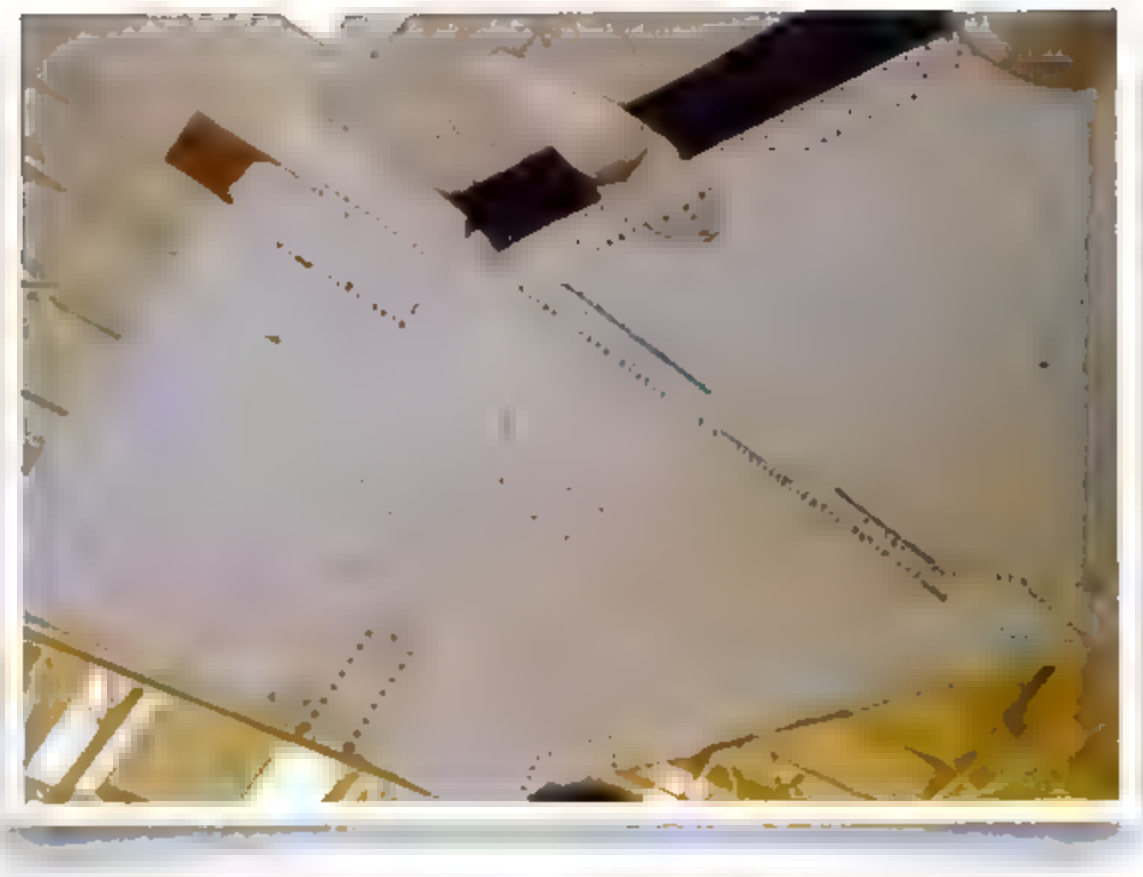
As mentioned in the previous chapter, by the time that TSR.2 was cancelled in 1965 a draft Naval Air Staff target had been drafted for a Passive ECM Tactical Aid which was apparently to be used in conjunction with TSR.2's RIWS. PETA was to be capable of recognising and locating the source of known radar signals and was to be used as an aid to locating targets for the Anti-Radar version of Martel. Besides using Martel in a purely tactical role the Air Staff were particularly interested in carrying the AR Martel along with a Nuclear weapon and thus using it as an offensive countermeasure.

PETA was also to be capable of intercepting target acquisition radars associated with SAM systems at a range of at least 50 nm. It was to be suitable for operation at Mach 2 at an altitude of up to at least 55,000 ft in addition to its low-level role. If possible, it was to be suitable for fitting in the ECM pod specified by NAST 837 which will be discussed below.

Radar decoys

Paragraph 66 (a) of OR 343 called for provision in TSR.2 of between 6 and 12 rocket-propelled radar and infra-red decoys which were to fly forwards and upwards from the aircraft. They were envisaged as being about 44 inches in length, 3 inches in diameter and weigh approximately 30lb. Radar decoys were seen as possibly having two applications. The first of these was to use decoys en mass to saturate the defences whilst the second and more practicable proposition was as a so-called 'foxer' to divert attention form a particular aircraft at a particular time. The idea in the latter instance was that when a missile tracking radar locked onto the aircraft, a decoy could be launched onto which the radar would transfer its lock. For this to happen the decoy must be a plausible and more tempting target than the parent aircraft and must thus have a velocity similar to that of the aircraft and this feature was not a characteristic of any form of Window.

The requirement for rocket-propelled radar decoys might have been the impetus behind Air Staff Target (AST) 3603 which was a design study for a rocket-propelled passive reflector decoy which was expected to be effective against both Pulse and Continuous Wave radars. In response to this OR, Faireys had undertaken a number of studies with a view to providing a suitable decoy for the Royal Navy's Buccaneer which is said to have been a development of the



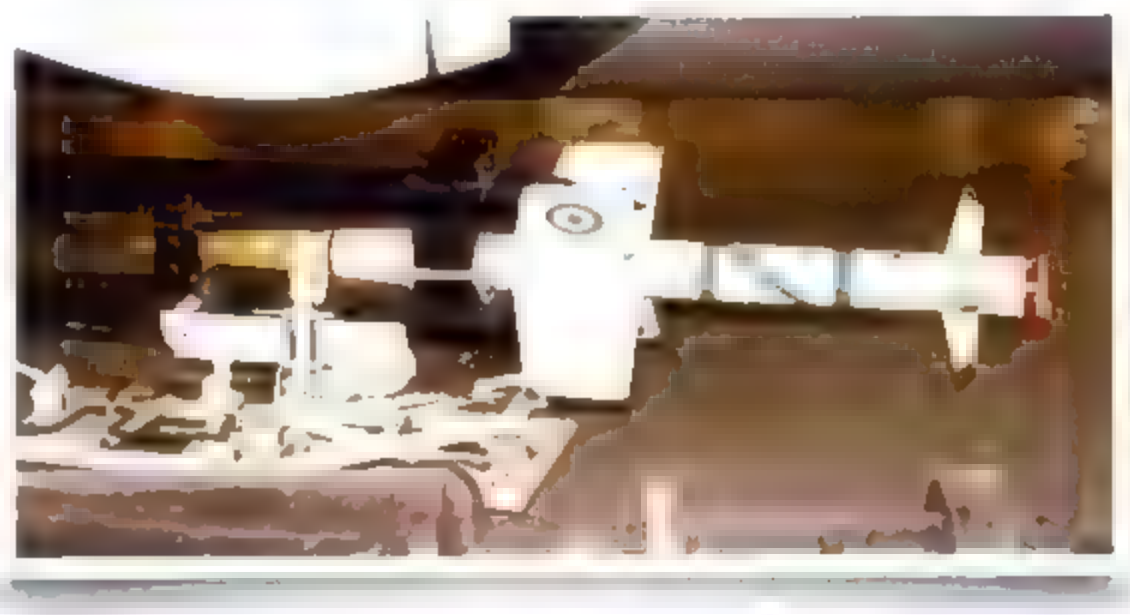
The aerial was asymmetric as can be seen in this view of the port wing tip when compared with the starboard wing tip on the previous page

Fairey Fireflash missile. This decoy is said to have weighed 415lb, had a length of 9ft 5in and had a maximum body diameter of 12 inches. It is not known if this decoy was ever actively considered for use on TSR.2. As far as TSR.2 was concerned the problem appeared to be that of reducing the RCS of the aircraft/decoy combination to a minimum whilst ensuring that the decoy had the largest possible RCS once deployed. To this end it was proposed that the decoys would be carried in either the forward part of the weapons bay with the nuclear stores in the rear or in wing pods. In view of the difficulty of designing such an installation and the limited number which it would be possible to carry, the use of such decoys was ultimately not recommended for TSR.2.

An alternative decoy

In November 1960 the DOR drew the attention of the RAE to developments of rocket-launched Window in the USA and asked that a design study be initiated with the object of determining the feasibility of applying this type of rocket to the TSR.2 to fulfil the requirement of paragraph 66 (a) of OR 343.

For some reason it appears to have taken over a year for anything to be done about this request as it was not until August 1962 that the RAE made an initial assessment of the suitability of the US QRC 142(T) window sowing rocket for use on TSR.2. This was intended to be primarily used in the lofting manoeuvre at the end of the low-level run-in to the target. The idea was that as the aircraft entered the climb, the rockets would be ripple fired thus placing a screen of Window between the attacking aircraft and any defences



The Fairey Fireflash missile is said to have been used as a basis for a rocket propelled passive reflector decoy. Its development was not proceeded with

Period EMI advert for TSR.2s reconnaissance system

which might surround the target. What became of this idea is not clear. There does not seem to be any further interest in the US system, perhaps because something similar was more readily available.

This was a variant of the Thomson Brandt Armaments 68 mm unguided rocket which could be fired from the 18 round Matra Type M155 described in Chapter 6. Besides the hollow charge armour piercing and general purpose high explosive fragmentation warheads, Thomson Brandt also produced an ECM chaff screening multiband decoy version of the 68 mm rocket. It must be stressed however that it is not known for certain that the RAF ever carried stocks of this variant of the 68 mm rocket.

Rapidly Blooming Window

Paragraph 66(b) of OR 343 called for 24 cartridges of explosively launched very rapidly blooming window to be carried. Rapidly Blooming Window (RBW) could be used for two purposes, unlocking a radar during medium- or high-altitude flight and jamming a radar during the target approach run-in the Nuclear Strike role. It was ultimately decided that TSR.2 should have a Window installation that was suitable for both purposes. A figure of between 90 and 100 RBW cartridges were required to be carried, each cartridge being two and a quarter inches diameter and five point three inches in length, this being identical to the dimensions of the IR flares described above. The only type of dispenser considered to be suitable for use on TSR.2 was a fixed honeycomb matrix pattern where the cartridge cases were retained after firing.

In June 1962 a number of proposals were put forward as to how these dispensers should be located on the aircraft.

Wing Pylon Pods

This installation comprised one pod mounted on the outboard pylon, each of which contained about 50 RBW dispensers. The approximate armed weight of these pods was 660lb including the pylons. Modifications to the airframe would be negligible since the existing wiring for the rocket pods at the outboard pylon stations would be used.

Whilst this installation would be suitable for all tactical roles the use of this configuration would suggest some loss in the armament-carrying capacity in the conventional tactical role and a penalty of 125nm in range on the standard 1,000nm sortie.

Wing Slippers

A similar arrangement concerned the use of slippers on the wings in place of the outer pylons which reduced the total armed weight of the installation to 560lb and the range penalty to 80nm. Again the airframe modifications would be negligible.

Wingtip nacelles

This proposal was put forward as a counter to the reduction in the underwing stores carrying capability which was inherent in the use of either the pods or slippers outlined above. The adoption of the wingtip nacelles would however necessitate the redesign of rib 12 and the tip of each wing as well as additional wiring runs. The nacelles would have an approximate armed weight of 500lb and would impose a range penalty of about 80nm.

Dorsal dispenser

This proposal was put forwards as a means of moving the RBW dispensers as far forward on the aircraft as possible. This dispenser would hold a total of 90 RBW cartridges and would have an armed installation weight of approximately 400lb imposing a range penalty of 22nm.

This dispenser would have to be built in sections replacing a total of seven existing access panels and feature flexible sections so that no longitudinal load would be carried by the airframe. One of the existing doors incorporated an air vent which would need to be repositioned if the dorsal dispenser was adopted and some difficulties might be expected from this. Some local strengthening of the fuselage skin might also be necessary to carry the cartridge reaction loads though it was thought that much of this would be offset by firing the cartridges in pairs, one to port and one to starboard which would thus cancel each other out. There was however always the possibility of a misfire and because some of the cartridges were located forward of the air intakes with the attendant danger of the engines ingesting cartridge debris, the line of fire was to be angled five degrees upwards.

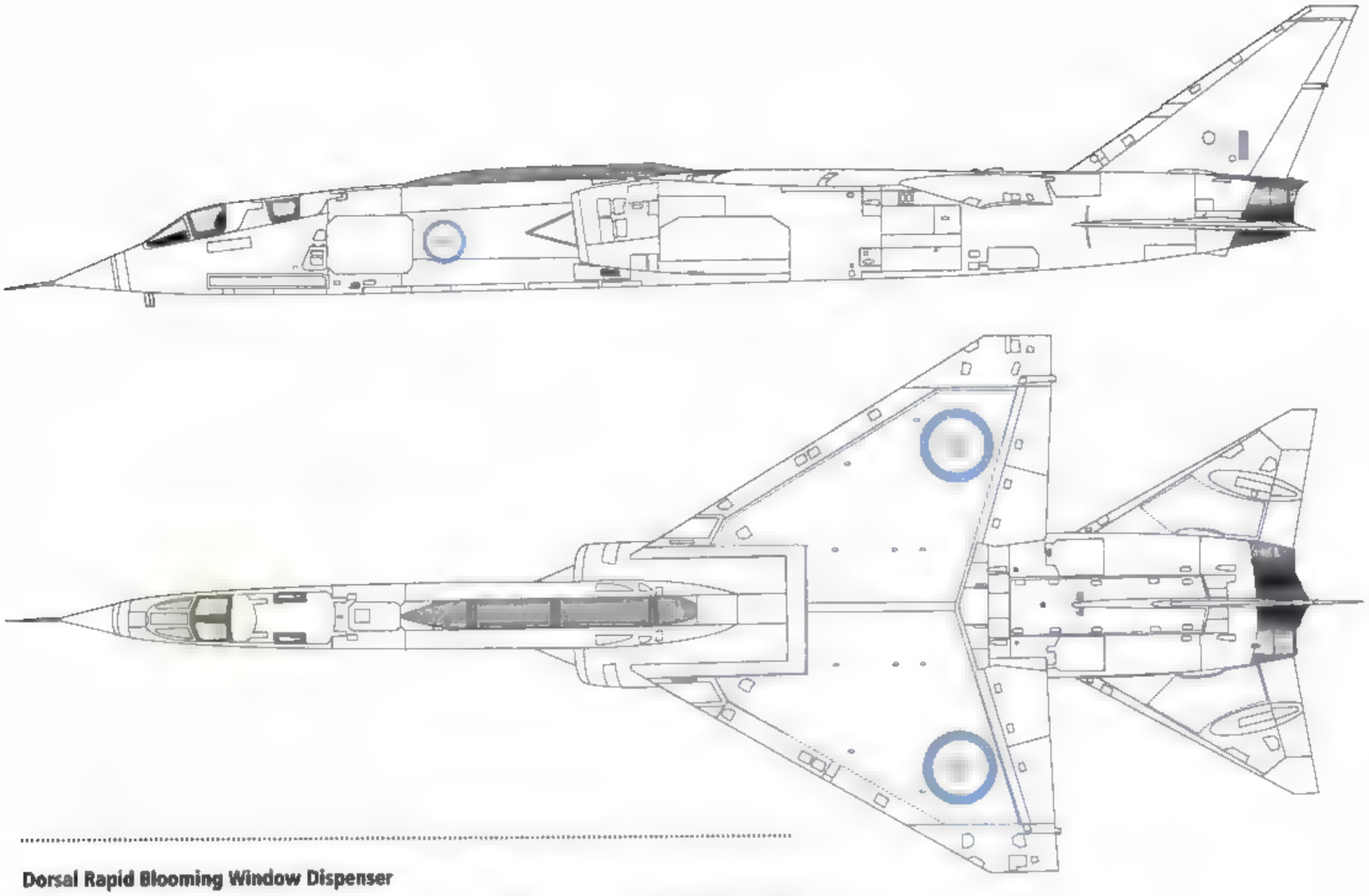
From a servicing point of view this scheme had the disadvantage that handling loaded dispenser sections might necessitate specialist equipment as each section might weigh 100lb and had to be handled some distance off the ground.

It was found that there was no place on the fuselage for the required number of RBW cartridges to be carried without some kind of local skin bulging and even then it was impossible to locate such blisters on the under surface of the fuselage as they would interfere with the Doppler equipment, SLAR, cameras, undercarriage doors etc.

The alternatives therefore appeared to be the dorsal installation about which there were aerodynamic concerns with regard to supersonic drag and directional stability, the wingtip nacelles which would involve some modification to the aircraft leading to more expense and further delays, the wing slipper or pylon mounted pod.

By 7 December 1962 it was becoming clear which way the wind was blowing on this issue as a loose minute from the Directorate of Operational Requirements to the MoA revealed that the Air Staff were willing to accept a pylon mounted RBW installation if the other installations under consideration were going to prove costly to develop and/or offer only marginal operational superiority. However, any pylon installation must be made capable of continuous carriage and jettison at speeds of up to at least 0.92M though supersonic carriage was desirable whilst having minimum effect on the radius of action. It was also to be capable of carriage in conjunction with any stores which would be carried on the inner pylons, thus implying that the RBW was to be installed on the outer pylons.

Though it is not known for certain exactly what the RBW pod for



Dorsal Rapid Blooming Window Dispenser

As it was thought that the RBW cartridges should be carried as far forward on the aircraft as possible, it was proposed that they should be carried in a dorsal dispenser in a manner similar to that shown here. This dispenser would hold a total of 90 RBW cartridges and would have to be built in sections replacing a total of seven existing access panels and feature flexible sections so that no longitudinal load would be carried by the airframe. Because some of the cartridges were located forward of the air intakes with the attendant danger of the engines ingesting cartridge debris, the line of fire was to be angled five degrees upwards.

TSR.2 would have looked like, there is a possibility that in overall design it might have been based on the RBW installation which was trialled on Canberra Mk 2 WH863 at A&AEE between 26 April and 2 June 1965. For these trials two standard Canberra wingtip tanks were modified to carry both conventional Gravity and Rapidly Blooming Window. Each pod was divided into two sections, front and rear. The forward section contained a Filtman-Langley stripper and dispenser together with a window dispenser magazine for the release of Gravity Window, whilst the rear section contained the RBW installation.

The RBW installation in each tank consisted of three matrices each containing 26 RBW cartridges giving a total load for the aircraft of 126 cartridges. One matrice was aligned pointing vertically downwards whilst the other two were angled off the vertical at approximately 45 degrees. The trials were considered to be so successful that it was recommended that this arrangement be adopted as standard for the whole Canberra T.17 force as quickly as possible. As this arrangement was subsequently adopted for the Canberra T.17 it is therefore likely that something similar might ultimately have been designed for use on TSR2 or alternatively TSR2 might have been equipped with the ECM pod to NAST 830 or ASR 853 which were envisaged as incorporating RBW dispensers.

Electronic jamming devices

Paragraph 66 (c) of OR 343 stated that one of a series of noise jammers or a deception jammer designed to confuse specific radar systems should be carried. Paragraph 67 went on to state that carriage in the weapons bay with the least limitation of the weapon load was acceptable and that if carried in an external pod some loss of performance of the aircraft was acceptable.

At the time, there were a number of equipments which were thought to be possibly suitable for use in TSR.2 which were collectively known as the Comprehensive Jamming System which was intended for use in the V-Bombers.

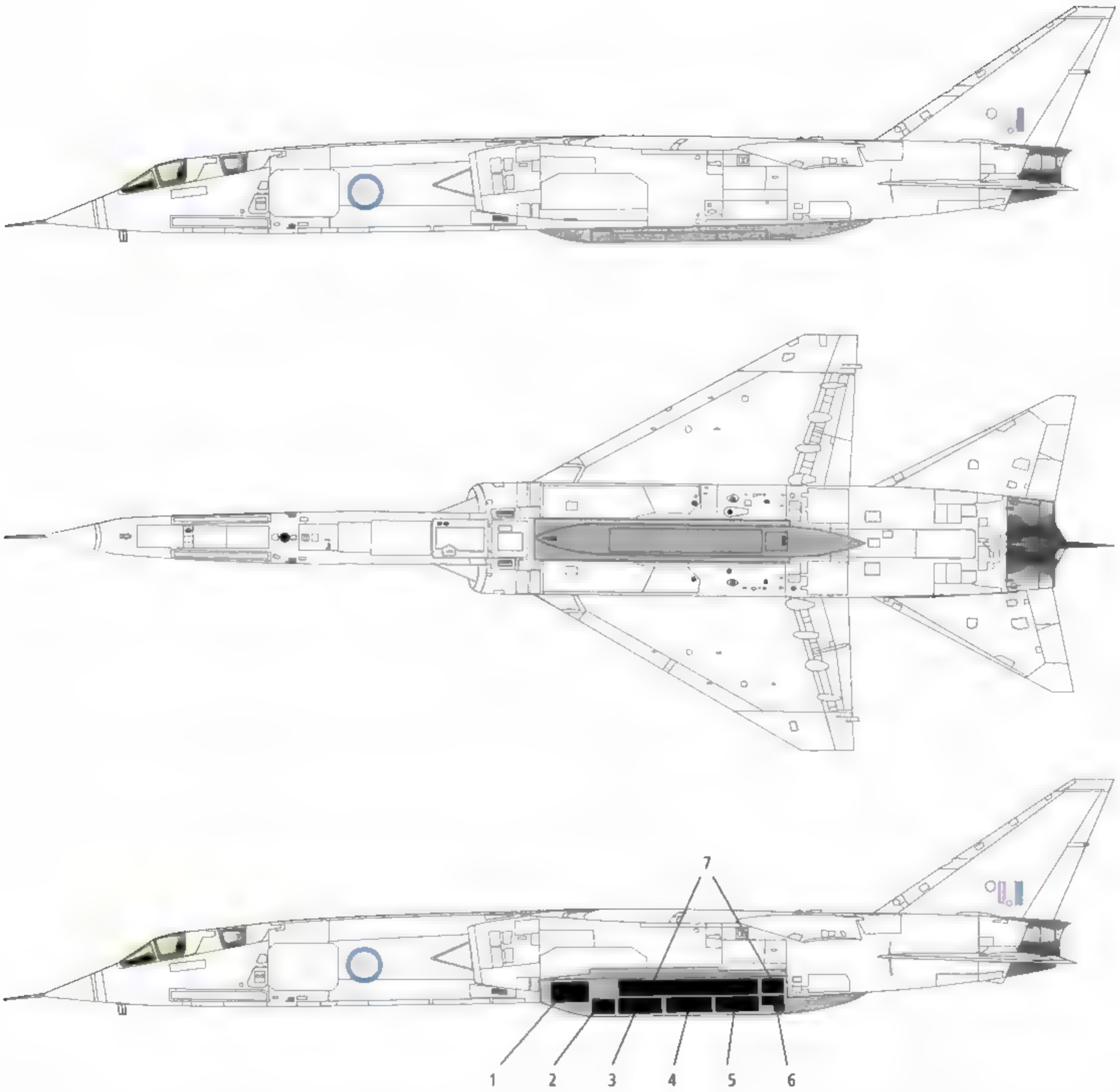
A study was conducted by Vickers Armstrongs into the question as to whether this equipment could be carried by TSR.2. In their report to the MoA on 5 April 1961 they concluded that it would not be possible and that in any event, they were of the opinion that they would be of negligible operational use.

The X-band jammer to OR 3585 was considered for fitting in the weapons bay but was found to be too big and difficult to adequately cool. When the question of carrying such equipment externally was examined it was found that in order to be aerodynamically acceptable, the smaller L band jammer to OR 3559 would have to be carried in a pod approximately 20 feet long and again would be very difficult to cool. In addition to this both types of equipment would make heavy demands on the power supply of the aircraft.

As a result of this report action was put in hand to delete the requirement in the OR 343 specification which called for the installation in TSR.2 of noise or deception jammers designed to confuse specific radar systems. However, it was not proposed to reduce the provision of space, power or cooling required for ECM so that should suitable equipment be devised during the lifetime of the aircraft it would still be possible to install it. Therefore the requirement for noise jammers was deleted by Amendment List 1 to OR 343 in August 1961.

TSR.2 as a specialist ECM aircraft

Even though the decision not to fit every TSR.2 with its own noise jammers had been taken, there were considered to be several differ-



Specialist Buddy ECM Capsule

It was originally thought that every individual TSR.2 would carry some kind of active ECM equipment in the form of noise jammers to defeat either surface to air radar or air to air radar. During the early 1960s there were several such devices under development for the V-Bombers which might have been suitable for the purpose but which ultimately proved to be too big to be carried by TSR.2.

In the light of this, it was suggested that some TSR.2s be used in a Specialist Buddy ECM role whereby they would carry nothing but ECM equipment in a special capsule in the weapons bay and be used to accompany other TSR.2s on their strike missions.

No hard evidence for what this capsule might have looked like, if it was ever actually designed, is known to exist. The illustration given here is therefore highly speculative but has been made up from the known physical properties of the ECM equipment available during the mid 1960s. For example the 'L' band jammer to OR 35599 is known to have been contained in a drum 44in long and 20in diameter whilst the aerodynamic shape of the Buddy Tanker capsule which is known to have existed has been adapted as it appears to be eminently suitable given the circular cross section of the jammers.

The numbered key is as follows 1) Electric Generator powered by a Ram Air Turbine. 2) Cylindrical RF Head for 'X' band jammer to OR 3585. 3) 'X' band AI jammer to OR 3585. 4) 'L' band jammer to OR 35599. 5) Extended frequency Range jammer to AST/OR 3607. 6) Tiltman Langley RCM Chaff Dispenser ARI 18051 and its associated Chaff magazine. 7) Associated and or additional equipment.

ent ways in which an aircraft in the specialist ECM support role might be employed. The first of these was as a stand-off jammer flying at altitude well outside the range of ground defences and providing cover under which the low-level strike aircraft could penetrate enemy airspace undetected. TSR.2 was not really seen as filling this role, which it was thought might be filled by an aircraft such as a V-Bomber.

TSR.2 was however considered suitable for the second main ECM role which was termed the 'Specialist Buddy' role. In this role a single or perhaps two or three TSR.2s operating in the Strike role might be accompanied by a fellow TSR.2 carrying nothing but jamming equipment and other countermeasures designed to saturate the defences during the critical strike period.

During the early 1960s an Admiralty working party considered both of these ECM roles in relation to the Buccaneer. An analysis of the problems posed in attacking a ship defended by guided weapons showed that if more than one Buccaneer were involved, then it would be profitable both from the point of view of hitting the target and recovering all the aircraft for at least one of their number to be used as a specialist ECM aircraft.

It was envisaged that the specialist ECM TSR.2 would be fitted to carry a special large ECM capsule in its weapons bay as an alternative to a bomb load. In parallel with this there would be a requirement for a substantial increase in the aircraft's electrical capacity to provide the necessary power. Nothing further is known of this proposed variant of the TSR.2.

New requirements

Despite the decision that TSR.2 would not carry active ECM which was taken during 1962, the problem of devising a suitable ECM fit for tactical aircraft did not go away and the MoD came up with a range of Operational Requirements for various ECM systems for use by tactical aircraft. Unfortunately, much of this work remains classified, but it is possible to discern the broad outlines of what these systems might have been from such documents which have been declassified.

NAST 830 ECM for Tactical Aircraft

It was recognised that the effectiveness of ECM equipment in Strike aircraft would depend upon the flexibility of the fit as it would be impossible for an aircraft to permanently carry EW equipment which would cover every conceivable threat. The aircraft would therefore have to carry only the most suitable equipment for any given operation. Thus Naval Air Staff Target 830 – ECM for Tactical Aircraft was issued. This asked for a study of ECM for protecting aircraft operating at low, medium and high level. As part of this study repeater jammers, noise jammers, and jammers capable of concentration jamming on a chosen frequency such as serach-lock-jam noise jammers were to be studied.

Aircraft Towed Decoy to NAST 836

Closely allied to the ECM issue was the provision of a decoy target of some kind. With large and expensive rocket-propelled decoys out of favour, the Naval and Air Staffs had agreed that countermeasures against low level SAM systems were needed and NAST 836 asked for a feasibility study to be undertaken of a towed decoy for use in the face of such defences. This was to be principally used as a countermeasure to radar-guided SAMs as whilst pulsed, continuous wave and pulsed continuous wave radars were all to be considered, little mention was made of defeating an IR guided missile. It was expected that the feasibility study would be completed during 1966 and the first service items were to appear in 1970.

In January 1964 the RAE published Technical Note No. RAD 859 entitled 'The Towed Decoy Countermeasure to SAGW Systems'. This note reviewed the present status of the towed decoy as a countermeasure to SAGW systems and briefly outlined the areas where further work was required before the device could be deployed as a military weapon.

The towed decoy was seen as being a body towed behind the attacking aircraft on a length of wire such that it lay within the same radar resolution cell as the attacking aircraft but offered a more tempting target than the towing aircraft. As it was not possible to tow a body of sufficient physical size to do this, it would be necessary to build an echo area enhancer in the form of a Travelling Wave Tube (TWT) repeater into the body which would give off a large radar return whilst the towed body could be of physically low weight and drag. Some experimental and theoretical work had been done on the problems of towing objects of this nature and it had been demonstrated that the towing of small aerodynamic bodies at speeds in excess of M=1.0 was quite practicable.

Used in this way, the towed decoy would be towed behind the aircraft on 100–200m of wire and involve a drag of a few hundred pounds at sonic speeds. It was thought that under normal operational conditions, the miss distance would be greater than 65ft which would be sufficient to reduce the lethality of small missiles used with low-level CW defences to an acceptably low level and thus reduce the kill probability of even large missiles to a low value. This type of decoy was referred to as a Towed Target (TT) type.

An alternative method of achieving the same object without putting the TWT in the decoy body where in an era of valves rather than solid state electronics it would be vulnerable to damage, would be to mount it in the towing aircraft and then transmit the amplified signal along the towing wire by a surface wave. In this case the only thing necessary at the end of the wire would be an aerial which could be designed to be small and aerodynamic thus giving low drag. This type of decoy was referred to as a Surface Wave (SW) type.

The note concluded that it would be possible to produce a towed decoy in the near future. Of the two types the SW was considered to have several important advantages over the TT type: it would be small and cheap, thus allowing the possibility of cutting the wire to jettison the target to be considered. This was a desirable feature since it would eliminate the need for a reeling-in mechanism. The big advantage over the TT type however was that the SW type was completely passive and was thus likely to survive missiles detonating in close proximity. Should a wire and aerial be lost it was thought that it might be possible to arrange for a new aerial to be deployed automatically. The big drawback to the SW type was that it was considered that the SW type would be more difficult to develop than the TT type as towed targets had been in use for training purposes for many years.

Infra-Red detector to NAST 841

This draft Staff Target asked that in the event of failure of all other forms of ECM a method be found to warn the crew of a hostile missile in the vicinity of the aircraft. It was suggested that the warning could be used to automatically trigger IR flares or such other countermeasures as might be considered to be effective in the prevailing situation. As a last resort it could give warning that evasive action should be taken. Like the other proposed ECM devices, it was expected that the study should be complete in 1966 and the first service equipment should appear in the early 1970s.

NAST 837 – Aircraft Pod for Electronic Warfare

The question of how such systems might be carried by an aircraft was addressed by Naval Air Staff Target 837 – Aircraft Pod for Electronic Warfare Equipment. The pod was to be capable of carrying one of the ECM devices from NAST 830 which sought to provide ECM for tactical aircraft, a towed decoy to NAST 836 and its ancillary services, dischargers for Rapidly Blooming Window and Infra-Red Flares, the Infra-Red Detector to warn of the approach of a

ALQ 101 pod fitted to a Jaguar. Introduced as an 'interim' solution to the RAF's ECM requirement for Tactical aircraft, this type of pod was also used by the Buccaneer

A Tornado carrying an early prototype of the ECM pod to NASR 1153 Active Electronic Countermeasure System for Tactical Aircraft under its port wing and Type N.1 bombs under the fuselage

hostile missile to NAST 841, and possibly a passive ECM tactical aid which at that time existed as an unnumbered draft NAST and is thought to have been based on the ELINT fit proposed for TSR.2 discussed above.

The exact date that these NASTs were issued is unknown. However Air Staff Requirement No. 356 for a Tactical Strike/Reconnaissance Fighter Aircraft with V/STOL Capability Issue 2 dated 28 May 1964 which became the Hawker Siddeley P.1154 states in paragraph 43 under the heading 'Electronic Warfare Equipment' that the aircraft was to be capable of carrying an ECM pod to NAST 837. This indicates that these requirements were contemporary to TSR.2 and whilst the author has seen no document directly linking TSR.2 with any of these NASTs it would seem to be a reasonable assumption that if TSR.2 had entered service, it might have been fitted with equipment developed to meet these NASTs or their descendants.

Revised requirements

An internal MoD memo dated 9 June 1966 reveals that following the feasibility studies which were carried out into these NASTs it had become apparent that entry into service of these devices would not take place prior to the fourth quarter of 1972 at the earliest. Even with a programme tailored to that timescale it was felt that there was a certain risk that the pod and towed decoy concept might not prove to be practicable with high performance aircraft. It was stated that the only way that the risk could be justified was as an attempt to do as much as was possible for the Phantom, Buccaneer and V-Force. There was also the side benefit that even if the pod proved unacceptable, then the electronics might be an asset to the F-111 ECM fit.

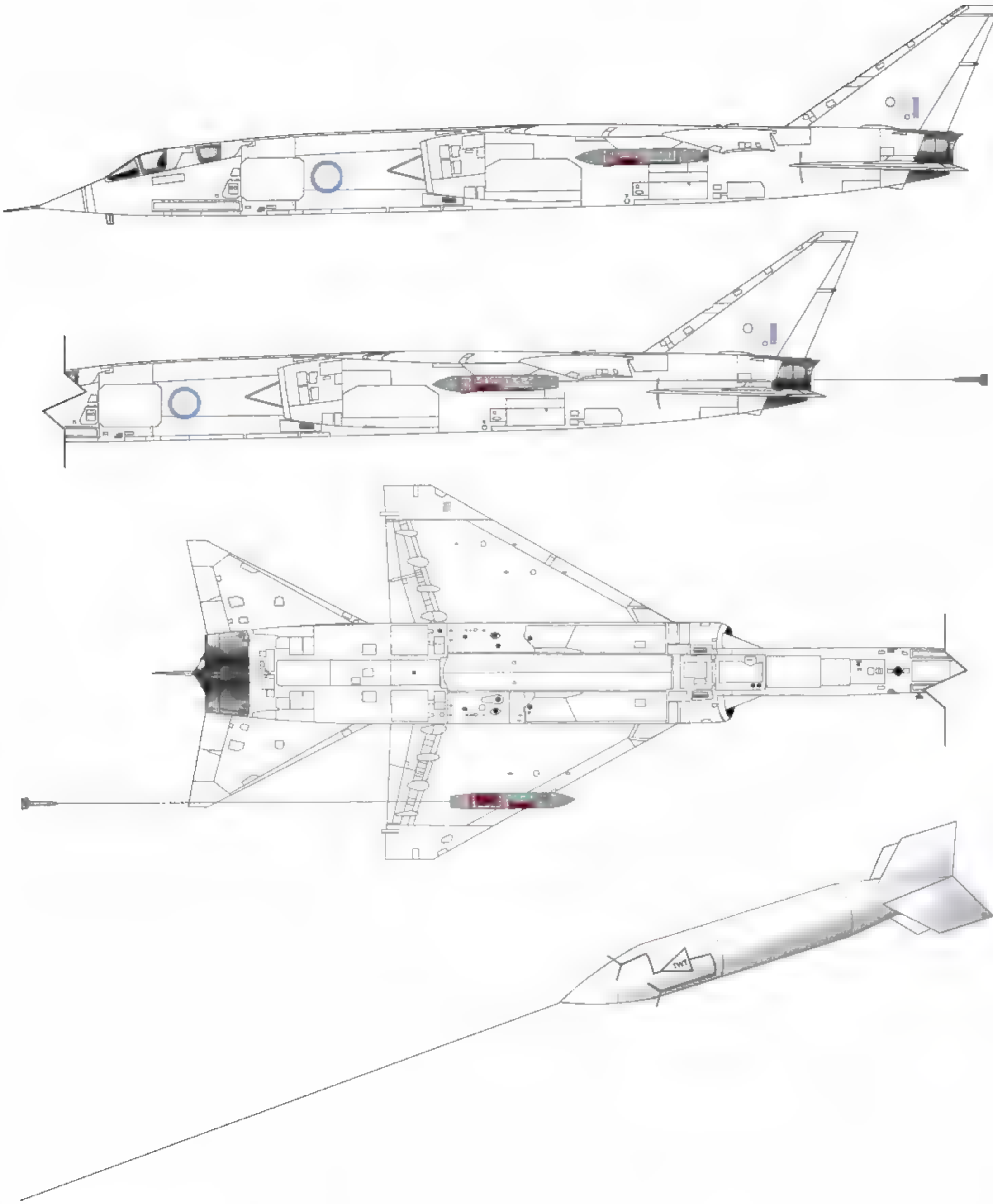
It is thought that as a result of this assessment a revised Naval Air Staff Requirement for an ECM pod, NASR 853 – Active Electronic Countermeasure System for Tactical Aircraft, was first issued in June 1967. It called for a range of countermeasures contained in a pod weighing approximately 1,000lb whose development was to proceed in two phases. The first phase was to cover the development of S/C and X-band jammers, Window and flares whilst the second phase would cover J-band jammers and towed decoys. Permission was given to proceed to competitive project studies in September 1967 with the relevant contracts being placed between March and August 1968

At about this time however, the MoD attitude to ASR 853 began to change. It was now required to provide solid frequency cover throughout the microwave band in place of the more selective coverage required previously. The competitive project studies were completed by August 1969 and are thought to have been tendered by Hawker Siddeley, ML Aviation Co. Ltd, Decca/GEC and MEL Equipment/Plessey. Exactly what the proposals these firms made is not clear but by April 1970 a pod 133 inches long and 16.5 inches diameter had evolved. It contained jammers in the fore and aft sections with a brake turbine cooling system to provide cool air for the electronics in the centre section. No attempt seems to have been made to meet the full NASR 853 requirement as it is thought that following the MoD's revised requirements for jamming cover, the resulting full NASR 853 pods were too large for asymmetric carriage on the Jaguar and other future small tactical aircraft.

This led to discussions being held between the MoD and Ministry of Technology which resulted in a reduced pod concept carrying active jamming equipment only, which the competing companies were invited to tender for. On 18 January 1971 ASR 853 Issue 2 – Pod Mounted Jammers for Tactical Aircraft was published. It stated that the complete pod was not to weigh more than 600lb, that it should be 133in long and that its diameter should be 14 inches if possible but was not to exceed 16.5 inches. The profile of the pod was to be such as to incur the minimum aerodynamic penalties. Both the pod and its mountings were to be able to with-

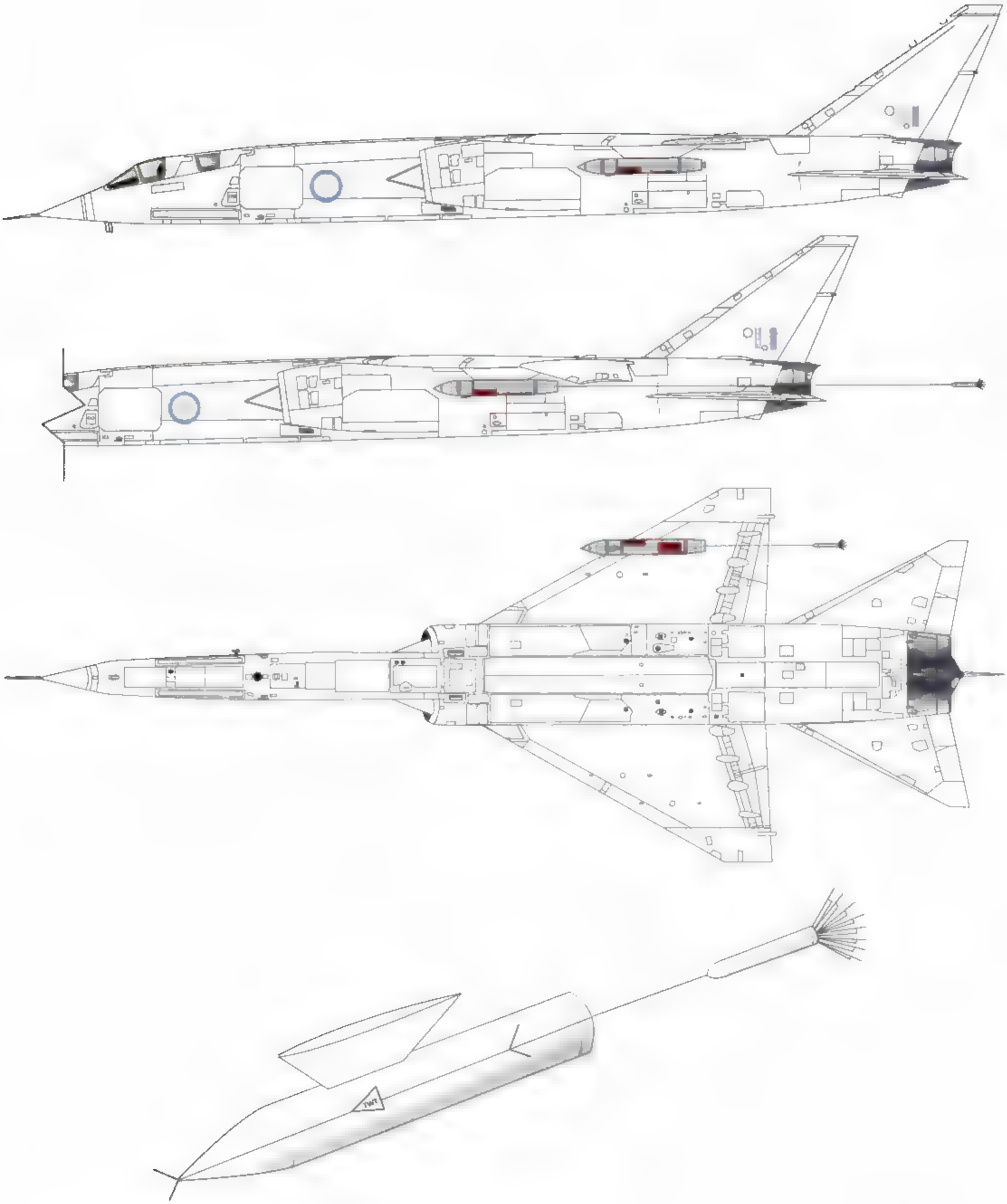
The Marconi Sky Shadow ECM pod which was the ultimate development of NASR 853

Close up of a BOZ-107 chaff and flare dispenser pod



Towed Target Decoy to NAST 836

In January 1964 the RAE published Technical Note No. RAD 859 entitled 'The Towed Decoy Countermeasure to SAGW Systems' in which the relative advantages and disadvantages of two different types of towed target were considered. The first of these was referred to as a Towed Target (TT) type and which featured an echo area enhancer in the form of a Travelling Wave Tube (TWT) repeater which was built into the body of the target which would give off a large radar return whilst the towed body could be of physically low weight and drag. Used in this way, the towed decoy would be towed behind the aircraft on 100-200m of wire and involve a drag of a few hundred pounds at sonic speeds.



Standing Wave Towed Target Decoy to NAST 836

The second type of towed target considered by RAE Technical Note No. RAD 859 was referred to as a Surface Wave (SW) type. An alternative method of achieving the same object without putting the TWT in the decoy body where in an era of valves rather than solid state electronics it would be vulnerable to damage, would be to mount it in the towing aircraft and then transmit the amplified signal along the towing wire by a surface wave. In this case the only thing necessary at the end of the wire would be an aerial which could be designed to be small and aerodynamic thus giving low drag.

stand G-forces from plus 8.5g to minus 3g. It was to be modular in construction so that either jammer could be easily removed for ease of servicing or replacement by a different jammer covering a different frequency band should the threats change radically during the expected life of the pod.

US ECM?

In the meantime, the failure of the original ASR 853 proposals to meet the RAF's needs meant that there would be ■ gap in the RAF's ECM capability. It was therefore proposed that the RAF should gain an interim ECM capability by buying existing ECM systems off the shelf pending the introduction of equipment tailored precisely to the RAF's needs. Therefore in mid September 1969, a joint MoD and Ministry of Technology team visited the USA for two weeks to determine what equipment the US might have available to meet the RAF interim ECM requirement which following cancellation of the TSR.2 and F-111 was now considered to be applicable to the Phantom, Buccaneer and Jaguar.

The equipment they examined included ALQ 71 which had already been previously rejected by the RAF, the ALQ 87 pod-mounted Noise Jammer; the ALQ 81 and 88 pod-mounted Deception Jammers and the ALQ 101 Noise and Deception Jammer pod.

Of these, only the Westinghouse ALQ 101 pod appeared to meet the RAF's needs and by April 1970 the RAF had formulated a requirement for 210 British pods for the strike/attack force or 210 Westinghouse pods or 50 Westinghouse for the most urgent front line requirements and 160 British pods for the rest of the force.

In June 1970 a recommendation was made that an order be placed with the US government to provide 50 Westinghouse active ECM pods with appropriate maintenance backing in the year 1972-73 to give protection to offensive aircraft in RAFG.

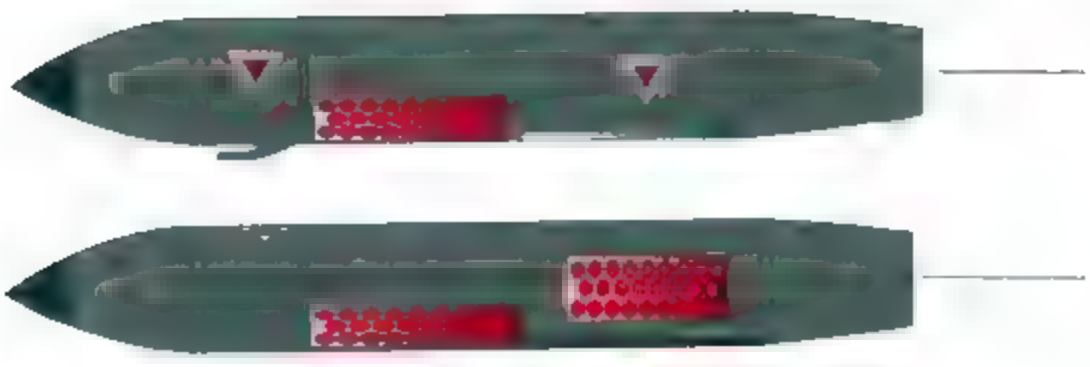
This recommendation is thought to have been put before the MoD Operational Requirements Committee in December 1970. The ORC endorsed the Air Force Department's requirement for AST 853 pod-mounted jammers for application to tactical aircraft and also endorsed the operational need for an interim solution pending the development and production of British equipment in 1976-77. The ORC concluded that the Westinghouse ALQ 101-4 was the only likely contender likely to provide a worthwhile capability in the short term even though it had only a small amount of growth potential.

As a result, in February 1971 a team from the MoD paid a further visit to the USA in order to verify the effectiveness of the Westinghouse AN/ALQ 101(V)-4 ECM pod. They also sought to obtain sufficient information on the supply and maintenance aspects of the pod so that it would be possible to justify its procurement to the MoD Operational Requirements and Weapon Development Committee. Loose minutes of this period mention the possibility of obtaining 76 pods which were intended for use by the Phantoms and Buccaneers of RAF Germany.

On 31 March 1971 the interim solution to ASR 853 Issue 2 was published based on the procurement of the Westinghouse ALQ 101-4 and as a result the RAF eventually procured an unknown number of Westinghouse ALQ 101 (V)-8 ECM pods circa 1972–73. This was the first model in the series to have the full length gondola beneath the original tube which is thought to have allowed more equipment to be carried thus increasing the frequency coverage found ■ be necessary following the US experience gained in Vietnam.

This 'interim' solution remained in service on RAF Jaguars until they were retired from service in 2007, some 30-odd years later. The British ECM pod requirement eventually seems to have reached fruition as the Sky Shadow pod which entered service with the Tornado in 1982 .

The RAF's requirements for what has since become known as chaff and IR flare dispensers have been met in a variety of ways such as the Phimat pod carried by Harriers and Jaguars along with flare dispensers scabbed onto the airframe and the Boz pod carried by the Tornado. The RAF has only recently acquired towed radar decoys for tactical aircraft which are currently being carried by Typhoons in their own dedicated wingtip pod and by some Tornados which deploy them from modified BOZ pods some 40 plus years after the requirement first emerged. It is perhaps significant that these decoys are of the SW type which was judged to be the better but more difficult to develop of the two possible types and that the Typhoon carries two of them, either as a countermeasure to two different types of radar or alternatively as insurance against combat damage.



Aircraft Pod for Electronic Warfare to NAST 837

The pod illustrated here is highly speculative in its design as at the time of writing, very little hard information ■ available on the designs which emerged to NAST 837. The illustration is based upon the known dimensions of one pod which had emerged by April 1970 which had an overall length of 11 ft and a diameter of 16.5 in.

It is suggested that the forward part of the pod might contain one of the ECM devices from NAST 830, the centre section might contain the explosive RBW matrices whilst the rear section might contain a towed target.

The Phimat chaff dispenser fitted to a Jaguar. This device has also been fitted to Harrier GR.5s and Tornado F.3s

With the introduction of the Typhoon, the RAF finally has a tactical aircraft capable of deploying a towed decoy target in combat. It appears that two such targets can be carried in the starboard wing tip pod

Postscript

Further Development – Variable Geometry?

HAD TSR.2 SURVIVED THE TRIALS AND TRIBULATIONS OF THE mid 1960'S and entered service, there is a small amount of evidence which suggests that the aircraft might have been further developed by the application of a proposal which offered considerable operational flexibility and which had already been proposed for TSR.2 during its preliminary design stages only to be rejected as immature technology in 1957. That proposal was 'Swing Wing' Variable Geometry.

Variable Geometry

The concept of Variable Geometry (VG) , sometimes known as Variable Sweep, is widely credited to Dr Barnes Wallis, inventor of the Geodetic form of aircraft construction first used in the R100 airship and subsequently in the Wellington, Warwick and Windsor bombers, the Upkeep and Highball bouncing bombs, and the Tallboy and Grand Slam earthquake bombs. It was whilst still employed within the Research and Development Department of Vickers (Aircraft) during 1945 that he first began to consider the advantages which might result from the application of VG to aircraft.

The basic advantages of the application of VG to an aircraft were seen as being that the wings could be moved into the fully forward position for take-off and for economical, long-range, high-altitude cruise or loiter on patrol, but could also be swept back for high-speed supersonic flight thus giving great operational flexibility within a single airframe.

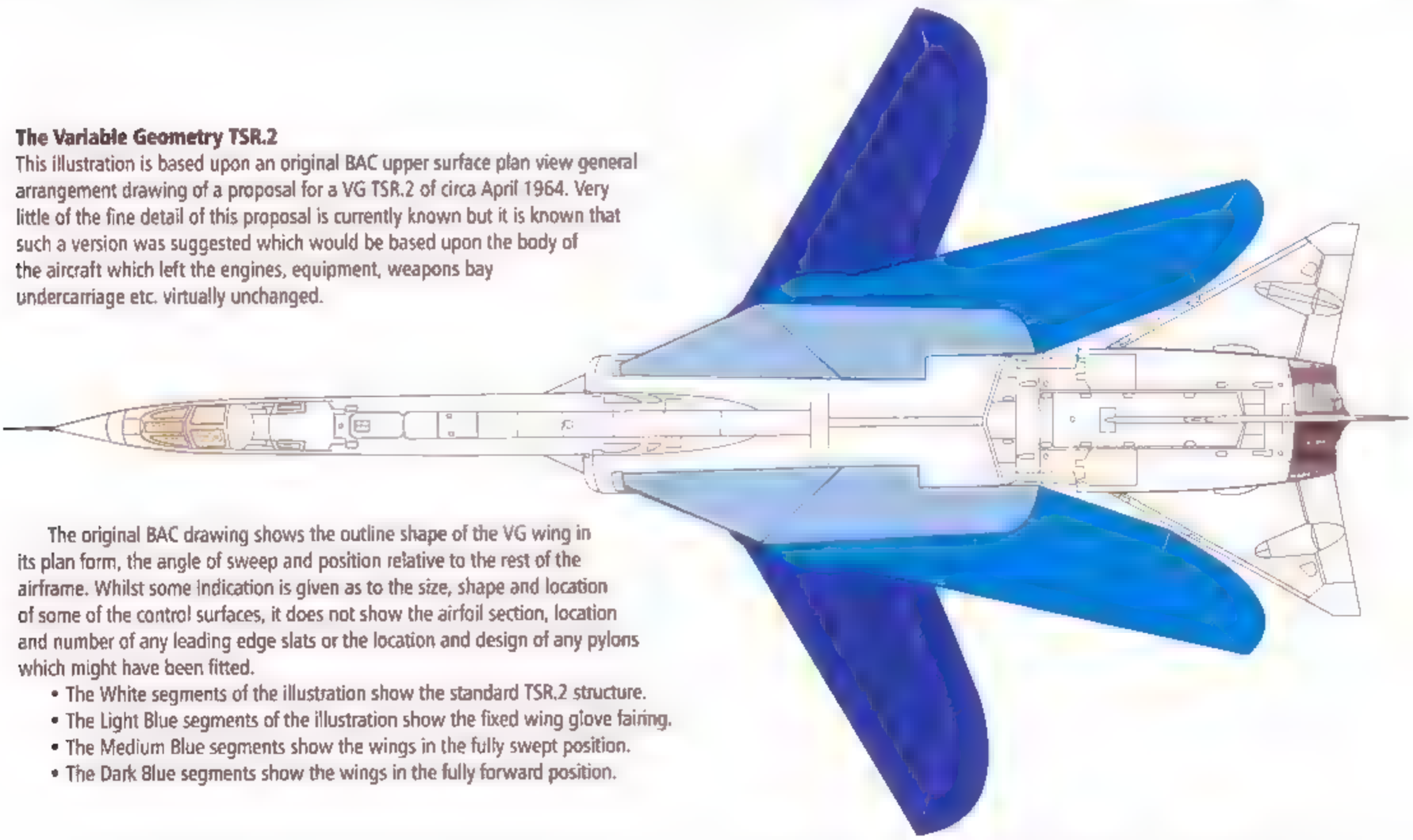
Initially, Wallis' ideas concerned the benefits which would be bestowed upon a long-range transport aircraft which was to be capable of flying non-stop and unrefuelled from Britain to Australia. However, in order to obtain government funding, a military use for the idea had to be found and this gave rise to the potential development of what became known as the 'Swallow' as a long range bomber. The Swallow had an arrowhead delta 'lifting' fore-body with VG wings and no tailplane. The engines were carried in pods at the wingtips which swivelled to remain head-on to the airflow as the wings altered their sweep.

Experiments were subsequently carried out using large subsonic free-flying models and rocket propelled supersonic models as well as tests in a wind tunnel and various kinds of engineering tests. Arguably the most important feature of Wallis' work was the use of a pivot for varying the sweep as opposed to the more complicated mechanisms incorporated in the Bell X-5 and Grumman XF10F-1 Jaguar, both of which had VG and were built in the USA and flown in the early 1950s.

Initially, funding for Wallis' research was provided by Vickers themselves and this was later supplemented by the Ministry of Supply, but following the 1957 Defence White Paper which saw major cutbacks on aircraft projects, British funding began to dry up and an approach was made to the USA for funding to be provided under the Mutual Weapons Development Programme. Thus Wallis discussed his work with NASA in November 1958 which led to their testing the Swallow design in 1959 before rejecting it, mainly on account of what was seen as its somewhat dubious engine layout.

Meanwhile in Britain, during 1958 Wallis had proposed a variant of the Swallow to meet OR 339 which was turned down on account of the 10 to 14 years it was estimated that it would take to develop. VG was then considered for TSR.2 at the very beginning of the project but was ultimately turned down. The reasons given for rejecting a VG wing at that time were as follows.

a) The in-service date of 1965 could not be met. The problems remaining unsolved could delay the aircraft by 5 years.
b) The Operational Requirement could be met by a fixed-wing aircraft powered by two Olympus engines and the shorter sortie which might be needed on a wider basis could be mounted from what were virtually Dakota airfields of which there were plenty. Whilst the TSR.2 was developed with a fixed wing, it could be



The Variable Geometry TSR.2
This illustration is based upon an original BAC upper surface plan view general arrangement drawing of a proposal for a VG TSR.2 of circa April 1964. Very little of the fine detail of this proposal is currently known but it is known that such a version was suggested which would be based upon the body of the aircraft which left the engines, equipment, weapons bay undercarriage etc. virtually unchanged.

The original BAC drawing shows the outline shape of the VG wing in its plan form, the angle of sweep and position relative to the rest of the airframe. Whilst some indication is given as to the size, shape and location of some of the control surfaces, it does not show the airfoil section, location and number of any leading edge slats or the location and design of any pylons which might have been fitted.

- The White segments of the illustration show the standard TSR.2 structure.
- The Light Blue segments of the illustration show the fixed wing glove fairing.
- The Medium Blue segments show the wings in the fully swept position.
- The Dark Blue segments show the wings in the fully forward position.

Prototype MRCA P.03 XX947. In what became the Tornado, Britain finally reaped some reward for all its pioneering development work on variable geometry

seen that there was much merit in the VG idea and in 1959 work commenced in the main design office at Vickers under a contract which was financially supported equally between the Ministry of Aviation and Vickers themselves. This programme also had some MDAP backing which mainly consisted of wind tunnel testing of models with various variable sweep configurations by NASA. These tests led to the abandonment of the Wallis Swallow concept in favour of a more conventional layout with fuselage mounted engines and a low horizontal tail.

Thus the United States was able to take the lessons learned from Wallis' work and apply them to their own VG project which ultimately became the F-111. Not only did this annoy Wallis as the F-111 was a conventional aircraft with a tailplane, but it also led to some considerable wrangling between Vickers and the Americans about possible patent infringements which were only settled when the Americans were able to prove that the F-111 did not compromise any British patents.

In Britain, the early 1960's saw various proposals made for experimental aircraft featuring VG wings. These proposals included a VG Swift, Lightning, Type 589 (which looked very like a scaled-down TSR.2) an experimental VG trainer and a VG TSR.2. Whilst none of these aircraft were ordered, work continued on developing the VG idea and it was felt that if this programme were to proceed and succeed, sufficient experience should be gained to enable a development of the TSR.2 with VG to go into service in the 1970s if the performance gains showed it to be worthwhile.

It was suggested that such a plan to fit TSR.2 with VG should be based on the body of the aircraft including power plants, equipment, bomb bay, undercarriage etc. being virtually unchanged. A TSR.2 in this configuration with a VG wing which appeared to be almost identical to that which had been proposed for the Vickers Type 589 was amongst the types illustrated at a secret mini-exhibition and seminar held by BAC at Warton to press the case for the development of VG in April 1964.

By this time all the Vickers VG work had been transferred from Weybridge to Warton and more studies were put in hand on the application of VG to light strike and trainer aircraft. One of these studies became the BAC P.45 of 1964 which it was envisaged would meet the need for a STOL fighter as well as meet the emerging requirement for an advanced training aircraft to replace the Gnat and thus bridge the gap between the Jet Provost and operational types such as TSR.2. The P.45 would have possibly been the perfect aircraft on which to introduce a practical swing wing and BAC pressed the British government to build two prototypes using the argument that it was time that Britain made use of all the development work which had been carried out over the past twenty years and actually put a VG aircraft into the air. It was thought that if the necessary action were taken the first P.45 could fly in 1968.

Thus by the time the TSR.2 was cancelled in April 1965 Vickers had been studying the concept of VG for twenty years, it had proposed a number of VG projects which were considered to be practicable including a VG version of TSR.2, and it was lobbying the government to authorise the construction and test flight of what would today be termed a technology demonstrator which it was hoped would lead to production of the P.45 STOL Fighter and Training aircraft.

The British government rejected the BAC P.45, and instead entered into an agreement with France to develop what eventually became the Jaguar and a new VG Strike Fighter aircraft. The new VG project which was intended to supplement the F-111 became known as the Anglo French Variable Geometry (AFVG) which would make use of BAC's specialist knowledge in this field and was to be British-led in design. Whilst the RAF did get its Jaguars which were actually used solely as strike aircraft, the French withdrew from the AFVG in 1967, the F-111 was cancelled in 1968 and the RAF requirement for an advanced trainer was eventually met by the Hawker Siddeley Hawk which entered service in 1976.

The cancellation of the AFVG led to much scrambling around in Britain which subsequently managed to hijack the European F-104 replacement programme leading to the Multi Role Combat Aircraft (MRCA) and Tornado. Such was the level of cynicism in what was left of the British aircraft industry by this time that it did not take long for the rumour to emerge that the letters MRCA actually stood for Must Refurbish Canberra Again.

With regard to the possible development of a VG version of TSR.2 illustrated here, the outline shape of the VG wing seen in plan form, its angle of sweep and relative position on the airframe have been taken from a BAC drawing of circa 1964. The BAC drawing only shows an upper surface plan view giving some indication of the size and shape of some of the control surfaces. It does not show the airfoil section, location and number of any leading-edge slats and pylons which might have been fitted, or their design.

Originally, it had been anticipated that TSR.2 would have an operational lifetime of some 10 years with full entry to service expected during 1969 and retirement expected in 1980. In retrospect, this retirement date now seems to be much too soon. For example, the Buccaneer which was to all intents and purposes TSR.2's replacement entered service in 1969 at about the same time that TSR.2 had been expected to and began to be phased out with the introduction of the Tornado from 1982. Even so, some aircraft soldiered on long enough to take part in Operation Desert Storm in 1990 before finally being retired from the maritime strike role in 1994. The Canberra, which TSR.2 was supposed to replace in 1969 actually retired from front line service with the RAF in July 2006. Thus there might be a case to be argued for the retention of TSR.2 well past its expected retirement date even if no further development had been undertaken as it was a very much more advanced aircraft than the Buccaneer, or even in some respects Tornado, to begin with.

If the TSR.2 had entered service with the RAF as planned in 1969, then it is possible that a VG variant might have been developed to enter service from the early 1980's onwards in place of the Tornado which would probably never have existed. Besides fulfilling the Strike and Reconnaissance roles as previously, it is possible that the VG wings might have made an interceptor version viable leading to the development of a TSR.2 Air Defence Variant in the same way that the Tornado was developed. If this had happened, then TSR.2 might still be in service today.

Having said that however, it is often said that the word 'if' is the biggest word in the English language.

If the Australians had ordered TSR.2...

If the project had been better managed...

If the media had been better informed and less prejudiced...

If the Labour Party had been better informed and less prejudiced...

If the engines had not delayed the project by so much time...

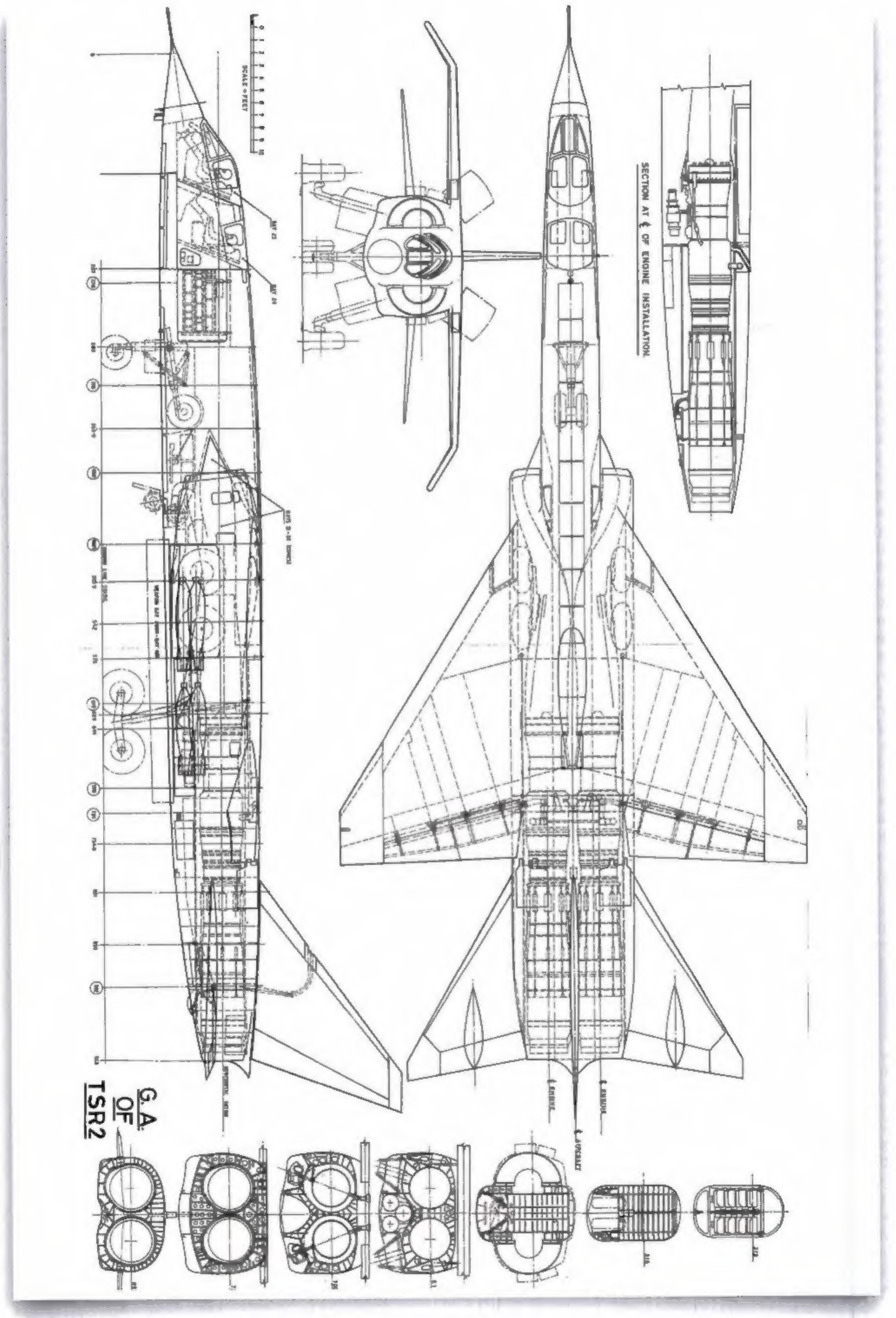
If fewer Labour votes in a few key constituencies had been cast...

If it would have actually all worked as advertised...

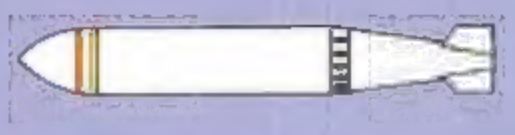
If the country could have afforded it...

If...

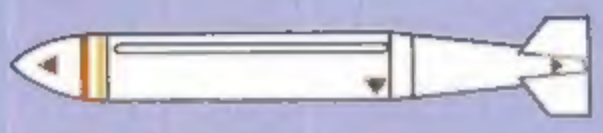
General Arrangement Drawings © BAC (circa 1964)



Nuclear weapons



WE 177A
It was initially intended that TSR.2 would carry two WE 177 tactical nuclear weapons in tandem inside the weapons bay. The WE 177A was 9ft 4in long and had a diameter of 16.5in. Following the cancellation of Skybolt, development of a thermonuclear version of this bomb was given priority.

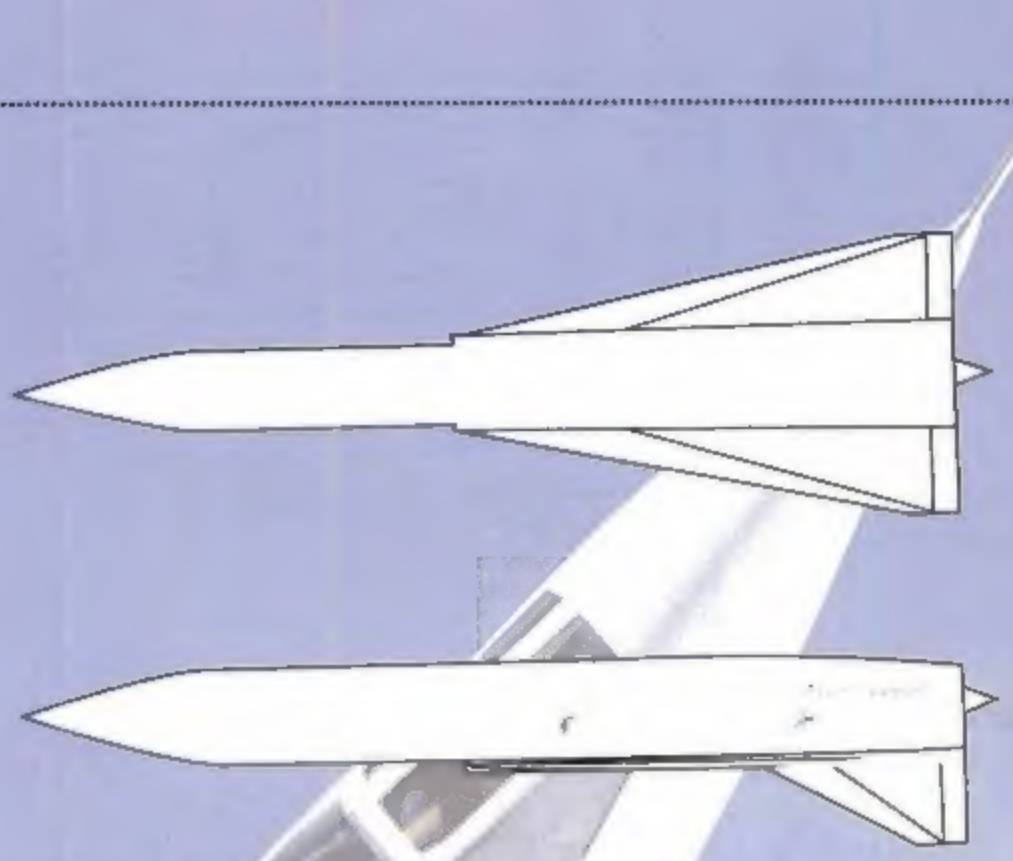


WE 177B
The WE 177B was developed as a direct result of the need to produce a stop-gap deterrent in the wake of Skybolts cancellation in December 1962. Initially intended to be carried by the V-Bombers, it was realised that this weapon would also bestow a strategic nuclear capability on TSR.2. The WE 177B was 11ft 1in long and had a diameter of 16.5in.

US Mk. 43 Bomb
The US Mk. 43 Bombs were provided for RAF use under Project E but with a length of approximately 14ft 6in and a diameter of 18 in were to large for two to be carried internally. In order that the same degree of target coverage could be maintained, it was therefore necessary to carry the two weapons externally under the inboard stores stations.

BAC Ballistic Missile
This BAC proposal appears to have been inspired by a Vickers proposal to carry an air launched ballistic missile entirely within TSR.2s weapons bay. The weapon illustrated here has an overall length of 235 in, a maximum diameter of 26 in and a nose diameter of 18 in. It was to have carried a single Polaris type warhead.

Skybolt
It was at one point suggested that TSR.2 might carry two Skybolt missiles above the wings. Ultimately, this suggestion came to nought when Skybolt was cancelled, but it would appear that any plan which might allow TSR.2 to carry this missile would have been fraught with difficulty.

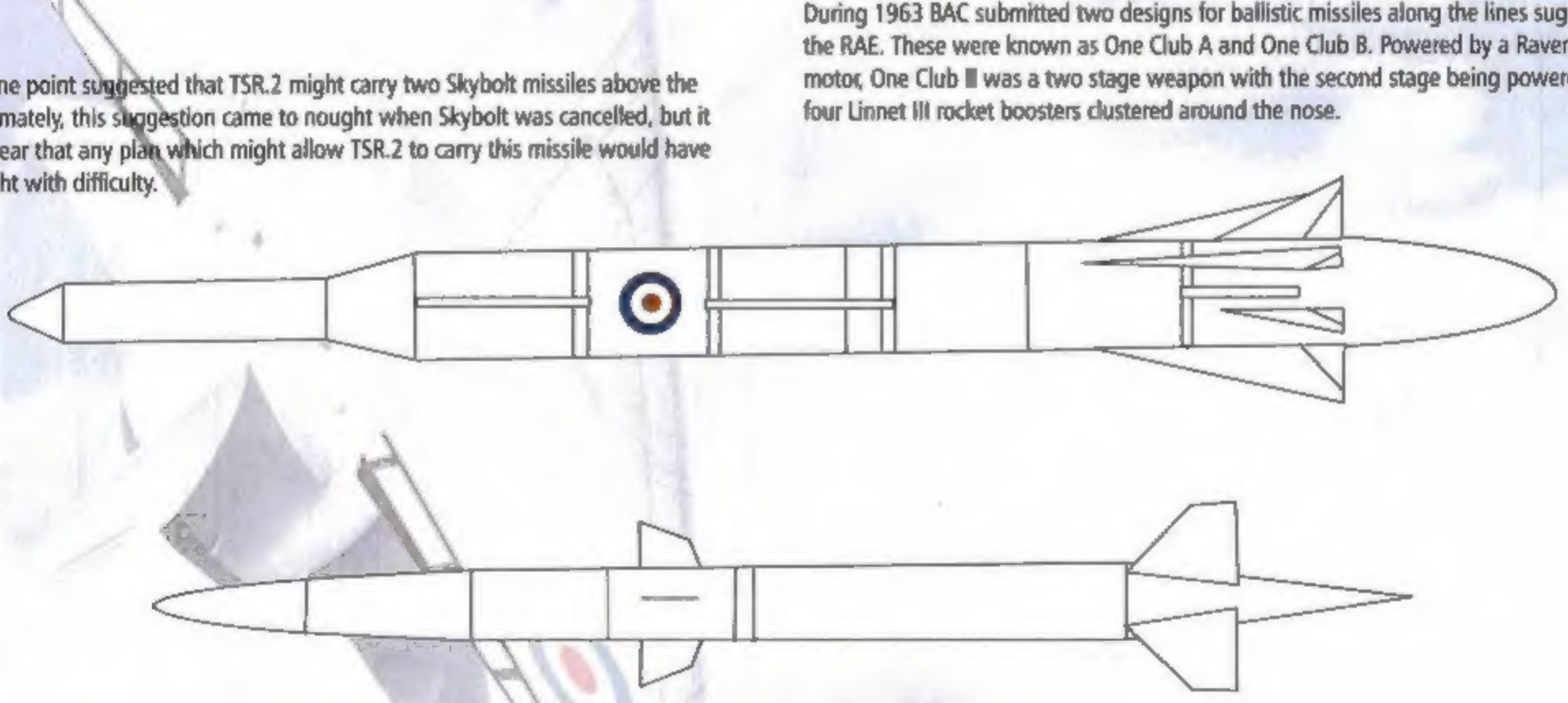


RAE TN 675 Single Jet Engine Proposal
The first of three proposals made by the RAE for a strategic missile which could be carried entirely within TSR.2s weapons bay, the weapon shown here was expected to be capable of delivering a 500 KT Skybolt warhead over a range of 225 nm at a speed of 0.95M

Grand Slam
As an alternative to Blue Water, BAC also proposed Project Grand Slam, 'System of Low Vulnerability for Tactical and Strategic Nuclear Strike from Aircraft'. This missile was to have been carried semi recessed into the weapons bay on the aircraft centreline.

RAE WE 1509 Ballistic Missile
The RAE proposed the development of a simple unguided ballistic missile which would consist of the nose portion of the OR 1177 Laydown bomb whose tail would be replaced by a finned rocket motor. This proposal was considered to be suitable for carriage by TSR2, the V-Bombers and the Buccaneer.

BAC One Club II
During 1963 BAC submitted two designs for ballistic missiles along the lines suggested by the RAE. These were known as One Club A and One Club B. Powered by a Raven rocket motor, One Club B was a two stage weapon with the second stage being powered by the four Linnet III rocket boosters clustered around the nose.



Blue Water
Two different proposals were put forward as to how the Surface-to-Surface Blue Water missile might be adopted for Air-to-Surface use to give TSR.2 a Stand-off capability. The first was made in 1960 and featured a single missile which was semi recessed into the weapons bay whilst the second, made in 1963, featured either one or two missiles of increased length and thus greater range carried beneath the wings.

TSR2

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